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DEVELOPMENT OF A QUALITY ASSURANCE METHODOLOGY FOR THE TECHNICA--ETC(U)

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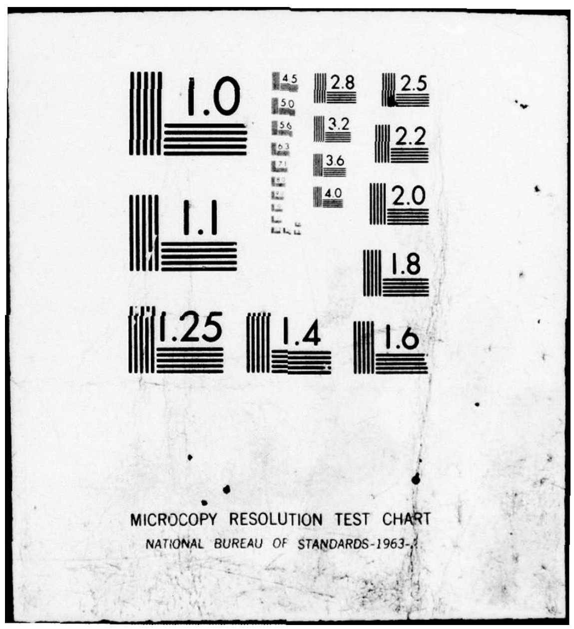
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DEVELOPMENT OF A QUALITY ASSURANCE METHODOLOGY FOR THE TECHNICAL INFORMATION GENERATION SUBSYSTEM OF NTIPS

Prepared by

HAGEMAN, INC.
Fort Worth, Texas

by

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Submitted To

Navy Technical Information Presentation Program
David W. Taylor Naval Ship Research & Development Center

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Volume I of this report provides: 1) a brief description of current Technical Publications development and Quality Assurance programs, 2) a description of NTIPS (Navy Technical Information Presentation System), 3) a detailed discussion of the content generation phase of NTIPS, and 4) a detailed discussion of a Quality Assurance program designed for contractor implementation during the contract generation phase.

Volume II of the report is a draft Quality Assurance Specification for Technical Publications and supporting Data Item Descriptions (DID's).

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The authors of this report wish to acknowledge the contributions made to this study by Navy personnel and to thank them for their contributions. Mr. Sam Rainey of DTNSRDC,* as program monitor, provided an essential and valuable interpretation of NTIPS* and his detailed review has enhanced the quality of the entire report. Mr. William G. Muller and Mr. Frank Ballitino of NATSF* have provided much of the background material and rationale used in development of the Quality Assurance approach described in the report.

***
DTNSRDC - David W. Taylor Naval Ship Research and Development Center

NTIPS - Navy Technical Information Presentation System

NATSF - Naval Air Technical Services Facility

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INTRODUCTION

1.1 GENERAL

This study, entitled "Development of a Quality Assurance Methodology for the Technical Information Generation Subsystem of NTIPS", has been prepared by Hageman, Incorporated (HI), of Fort Worth, Texas, in accordance with subcontract No. 7040 to Operations Research Incorporated of Silver Springs, Maryland, under prime contract N0019-78-C-0175. This study is designed to address the problems and requirements of a Quality Assurance (QA) program as part of the overall Navy Technical Information Presentation System (NTIPS) development effort. The following paragraphs describe the study methodology, and present a description of the current technical manual and QA programs, as well as a functional description of NTIPS. The study itself focuses on the Technical Information (TI) Generation phase of NTIPS and the development of a QA system supporting that phase. Quality Assurance, for the purposes of this study, is defined as the planned systematic activities and actions necessary to provide adequate confidence that the item or product conforms to established technical requirements. A QA philosophy is developed and requirements are identified. Finally, a procurement specification for a QA program, supporting Data Item Descriptions (DID's), and a sample Contract Data Requirement List (CDRL) were prepared.

1.2 APPROACH

The approach used in the study included a review of current Navy Instructions, Technical Manual and QA Specifications, and DID's. In addition, research reports in the area of readability and comprehensibility and NTIPS were reviewed. Both Integrated Logistics Support (ILS) and Instructional System Development (ISD) documentation were included in the review. Following the review of the documentation, listed in Appendix "B" of this report, a functional description of both current technical publications procurement and of NTIPS was prepared. An attempt was made to include all essential processes. The processes were then analyzed to determine feasibility of QA program monitoring.

A QA program philosophy was synthesized. Within the framework of that philosophy, NTIPS processes were analyzed and QA requirements developed. Based on the QA requirements, formal procurement documentation was prepared in the form of a specification and DID's. The procurement documentation was further supported by including a sample CDRL as an example of the utilization of the DID's.

1.3 SCOPE OF CURRENT STUDY

It was determined in an earlier HI study, "The Potential Impact of an Effective Quality Assurance Program for Navy Technical Publications on Navy Training and Training Equipment Procurement", [1*] that further study should be directed to specific areas of NTIPS. The study indicated that the QA process from the replication phase through the verification phase is reasonably well covered by existing procurement documentation, but that procurement documentation for the QA process prior to replication is essentially non-existent. The area in which few QA dollars and little QA effort is expended occurs during the TI generation phase. It appears that approximately twenty percent (20%) of the QA effort is expended prior to replication and eighty percent (80%) following the initiation of replication. The contractor, on the other hand, has already expended on the system at least eighty percent (80%) of his effort prior to replication and only twenty percent (20%) following the initiation of replication. Thus it would appear that twenty percent (20%) of the QA effort is now applied to eighty percent (80%) of the contractor Technical Publications effort. This disparity in resource utilization may be a contributing factor to current TI problems. Thus, this study program is directed toward those activities which occur prior to replication in the NTIPS TI Definition and TI Generation phases. The TI Definition phase is primarily a Navy responsibility to which QA requirements are not directed. The TI Generation phase is primarily a contractor responsibility to which a QA program is applicable and essential. Thus, it is appropriate that a major effort in definitizing an effective QA program be constrained to the TI Generation phase.

[1*] Note: References to corresponding numbers are given in the Bibliography, following Section 5.

However, in order to understand all of the implications of the processes which occur during the TI Generation phase, it was necessary to review and define as precisely as possible the NTIPS process. Accordingly, the initial parts of the report address NTIPS in order to identify NTIPS functional processes. The development of QA requirements, however, was limited to the TI Generation phases of the program.

1.4 CONTENT OF THE REPORT

Section 2 of the report provides a description of a Technical Publications development process Quality Assurance program which is representative of current programs, followed by a brief description of NTIPS. Section 3 of the report contains a detailed discussion of the TI Generation phase of NTIPS. Assumptions made in generating greater detail are provided in order to support the discussion. Section 4 of the report describes the QA requirements derived from the detailed analysis of the TI Generation phase of NTIPS described in Section 3. Section 5 of the report is a brief presentation of the results and conclusions of the study. In addition to the Bibliography, the report also contains two Appendices: 1) Appendix "A", Glossary of Terms, and 2) Appendix "B", Review Documents Matrices.

SECTION 2
DESCRIPTION OF PROCESSES

2.1 CURRENT PROCESSES

The current Technical Information (TI) development processes and the QA of the TI will vary slightly from one contractor to another. Therefore, the discussion and sequence of the TI production process presented here are considered typical of, but not necessarily applicable to, any particular contractor. The process, as presented, is the result of reviewing several TI production processes documented in the literature.

2.1.1 TECHNICAL PUBLICATIONS DEVELOPMENT

A diagram depicting a typical current TI development process is given in Figure 2-1. A description of the process by the block numbers follows. This section does not reflect recommended NTIPS procedures.

Blocks 1 and 2 describe the input information the writer will use to prepare the technical information. Block 1 describes the "in-house" input or the data available at the contractor facility. These include items such as engineering design drawings, maintainability data, safety or hazard analyses, vendor brochures and data, support equipment specifications, task analyses, and similar information. This block will also include information obtainable from conferences with design, maintainability, manufacturing, training, safety, or other personnel. The customer data input represented in Block 2 are items such as contractural specifications for the technical information, manual specifications, equipment unsatisfactory reports (UR), reports on Government Furnished Equipment (GFE) items, and other data that the customer supplies relative to the TI.

In Block 3, the writer prepares an outline of the TI to be presented from the information supplied in Blocks 1 and 2. From the outline the writer determines requirements for text and illustrations as represented in Block 4. Some judgment is required by the writer to

ascertain the level of detail to be presented in the text and illustrations, and the decisions are generally based on past experience.

Block 5 indicates the completion of a draft of the text. The illustrators then start preparation of the art work (as shown by Block 6) and the Engineering Department reviews the draft of the text as represented by Block 7. The Engineering review is a technical review of the content of the text draft.

The illustrators' work results in preliminary art work as cited in Block 8 which later results in the art work for the manuscript.

Comments, deficiencies, and discrepancies resulting from the engineering review are incorporated as corrections to the draft text in Block 9. The corrected or revised text is then combined with the preliminary art work to produce the preliminary TI copy in Block 10.

The maintenance procedures as described in the TI are then validated in Block 11. In the validation process, the TI is used, usually by the writers, to perform the specific task or series of tasks on the specified hardware. This, in essence, is a functional test of the TI performed by the contractor technical writer.

The Block 12 art revision and Block 13 text revision requirements may result from the validation of the TI. After required text revisions are made in Block 13, the text is edited in Block 14. The editing is generally performed by the more experienced technical writers with emphasis on the grammatical structure of the text. If the validation process uncovers no faults in the TI, then these revision requirements drop out.

After editing, the reproducible typographic composition of the text is carried out in Block 15. Block 16 describes the task of proofing the text which is performed by the writer and/or editors. During preparation of the text, the art work is being readied for reproduction as shown in Block 17.

In the task represented by Block 18, the final art work and proofed text are assembled into a reproducible master. At this stage, comprehensive production quality checks, represented by Block 19 are made. These checks generally include title page and front matter format, text completeness and continutity, figure references and titles, proper page numbering, classification and specification compatibility. The Block 20 corrections are made to the manuscript as required. Verification activity represented in Block 21 is a final test of the manual as to its applicability to the hardware and task for which the TI was written. Verification is a formal process through which users (Navy personnel) determine the adequacy and accuracy of the technical data by actual performance of the procedures defined by the information. The user review results in identifying omissions and correcting deficiencies such as inaccurate procedures, or inaccurate part numbers, tolerances, torque values, instrument settings and readings, found in the TI. These required corrections are represented by Block 22.

Copies for Navy review are produced as designated in Block 23 and the review package is sent to the customer as denoted in Block 24. At the completion of the review, the customer either provides comments, Block 25, or approves the review copy, Block 26. If the customer has made comments for incorporation into the TI, these are incorporated in Block 27 and the copy is again sent to the customer for review and approval as indicated by Block 28.

Following customer approval, the TI package is released for production. The specified production process depends upon the medium or media of the TI. Block 29 represents the release for production and Block 30 represents the distribution of the TI to the different using activities.

2.1.2 QUALITY ASSURANCE (QA)

Currently, Quality Assurance (QA) of TI is minimal within the typical production process. Only three formal inspections are performed during the process. These are validation, production quality checks, and verification; and are represented in Figure 2-1 by Blocks 11, 19, and 21 respectively.

The validation procedure is classified as formal because it is a contractually required procedure that ensures that the TI accurately supports the weapon system and equipment being documented. The contractor is responsible for all validation procedures and the incorporation of corrections for all technical and other discrepancies recorded during validation. Though this is a contractually required procedure and aids in assuring the quality of the TI, the procedure does not necessarily involve QA personnel, per se, of either the contractor or the customer.

The production quality checks include all the composition and format details of the TI. These checks are usually performed by more experienced writers within the technical writing group. They may be designated as QA personnel within the group, but usually report to the same management as the writers. The checks are generally thorough and documented, thus providing a degree of formality.

Verification is another formal process in which the Navy personnel determine the adequacy and accuracy of the TI by performance of the procedures using the TI. This is the customer's check to assure the functional adequacy and accuracy of the data. Usually only customer QA personnel become involved in this process.

The customer reviews of Blocks 25, 26 and 28 are not classified as strictly formal inspections because the amount of inspection performed here is minimal in most instances. These reviews are often only a formality for final acceptance of the TI. When inspections are performed, they are similar in nature to those performed by the contractor in Block 19.

Several less formal reviews and inspections are performed during the production of the TI that aid in assuring the quality of the information. However, these are usually not contractural requirements and are generally not documented by formal QA records, either those of the contractor or those of the customer. These informal reviews and inspections include engineering reviews (Block 7), editing (Block 14), text proofing

(Block 16), and the checking of the art work during its preparation (Blocks 6, 8, and 17). The engineering review is the first technical review in the production of the TI and is the only informal review or inspection performed by personnel outside of the organization preparing the product. Editing and text proofing are performed by personnel within the technical writing groups. Art work is reviewed and proofed within the illustrations group.

In summary, the contractor performs four informal checks and two formal checks to assure the quality of TI products. The customer performs one formal proofing of the information during the verification procedure and one quasi-formal review in conjunction with the final approval of the material for production and distribution.

None of the QA inspections of the contractor are performed by personnel independent of the technical publications organization. Most of the formal checks or inspections are made after the TI product is essentially complete.

2.2 NAVY TECHNICAL INFORMATION PRESENTATION SYSTEM (NTIPS)

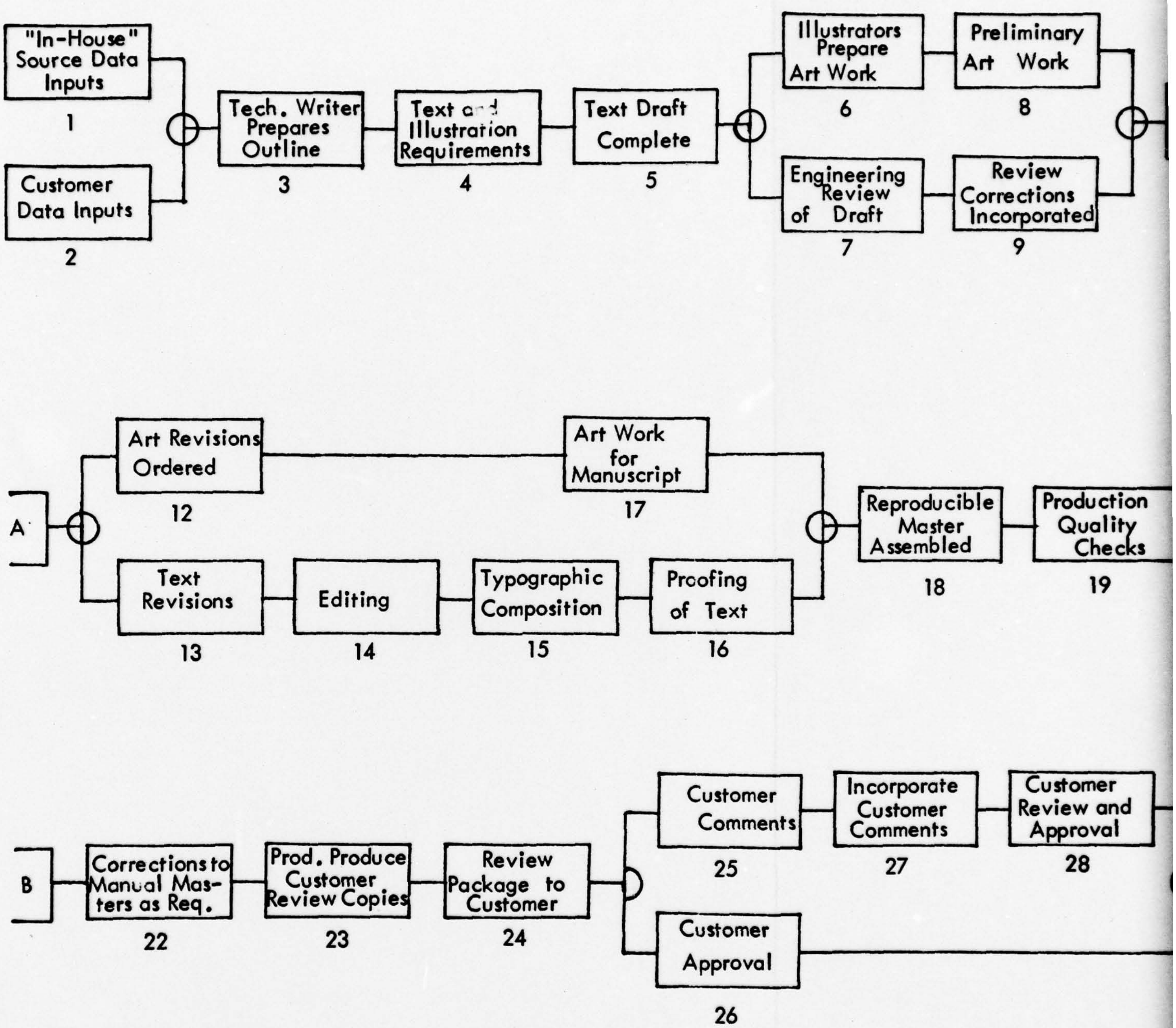
2.2.1 GENERAL

The objective of the NTIP Program is the development of a Navy-wide system for the generation, distribution, control and update of TI required for operation, maintenance, training, and logistic support of hardware systems. NTIPS goals are to improve fleet material and training readiness by improving TI comprehensibility and useability, and by delivery of TI prior to hardware delivery; and to reduce training time and life cycle costs.

The Navy decision coordinating paper for NTIPS dated 8 March 1978, [2] indicated that NTIPS may be divided into five major subsystems. These are:

1) The pre-contractual phase called Technical Information Definition
2) Technical Information Generation which is the initial contractual phase and includes draft preparation and draft validation

TYPICAL CURRENT TECHNICAL INFORMATION DEVELOPMENT PRC



SYMBOL DEFINITION

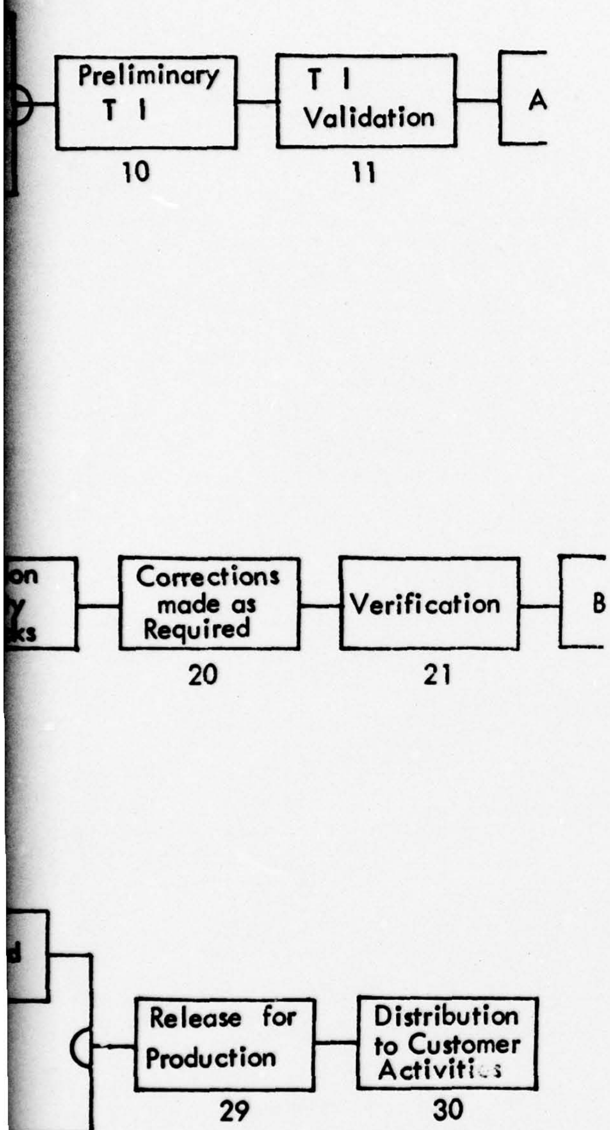
The Symbol ⊕ indicates the logical AND, which means both (or all) are necessary

The Symbol indicates non-exclusive OR, which means one or both (or any) may obtain

The Symbol ⊣ indicates the exclusive OR, which means one or the other but not both (or all) may obtain

FIGURE 2

PROCESS



Preliminary T I
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T I Validation
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Verification
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Release for Production
29
Distribution to Customer Activities
30

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2

3) Technical Information Replication which describes the phase during which draft material is printed or processed in microform or other medium in final format
4) Distribution and Delivery which follows the Replication phase
5) Update and Correction Phase

2.2.2 NTIPS PROCESS

A more recent and far more detailed block diagram[3] describing the NTIPS process is shown in Figure 2-2. The meaning of the blocks and their relation to the five NTIPS phases are discussed in the following sections of the report. This discussion is intended to provide essential and background information for the analysis of the Technical Information (TI) Generation phase QA requirements, which, as described earlier, is the central focus of this study, i.e., the development of QA requirements for the TI Generation phase of NTIPS.

Blocks 1 through 6 of Figure 2-2 represent the information and data required for the initial NTIPS activities. Block 7 represents the job task analysis which is implemented to identify maintenance and operating tasks demanded by the system. Blocks 8 through 11 represent the products of that analysis. Block 12 represents the summary of that analysis in terms of the information needed in the technical publication. It is a preliminary definition of the information requirements and technical publication content. Block 14, entitled "The Head/Book Trade-Off", has as inputs Blocks 12 and 13 which identify the information required and the currently available training technology. The Head/Book Trade-Off analysis results in the information described in Blocks 14.1 through 14.4 and 15.1 and 15.2. The purpose of the Head/Book Trade-Off is the non exclusive division of technical information requirements for technical publication and training. Training requirements are established for both OJT and school training, as well as the description of the technical documentation needed for training support. Block 16, 17, and 18 represent the analysis process for identifying medium requirements, level of detail of topic treatment and TI formats as well as comprehensibility criteria for the final documentation. Blocks 19 and 20 describe the task of developing cost estimates and preparation

of RFP's which include the preparation and/or selection of Technical Manual Contract Requirements (TMCR), CDRL, Specifications, and DID's for procuring operation and maintenance documentation for the equipment of the system. Block 21 represents completion of those processes from RFP preparation through the letting of the contract and includes proposal evaluation and contract negotiations. Block 21 represents completion of the TI Definition phase of NTIPS. Since TI Definition is a Navy task, QA requirements are not applicable to any of the tasks or activities described in this stage of NTIPS. However, Navy QA personnel must prepare sections of the RFQ and verify the fact the appropriate QA DID's and Specifications have been included in the bid package prepared by the Navy. Thus, while no formal QA activities occur during the TI Definition phase there is a very significant and essential effort in preparing for an effective QA program during and following TI Generation. This effort must include a requirement for the contractor in his proposal to prepare and submit a formal, detailed QA Program Plan (QAPP). If this is not done by Navy and contractor in turn prior to the contractual agreement with the contractor, no effective QA program will result. Effective planning is essential to the successful implementation of an effective QA program.

The next series of blocks describe the TI Generation phase which is of major interest to this study. Blocks 22 and 23 represent on-going program activities which include the design and manufacture of hardware, the implementation of logistic support analysis and the preparation of the logistic support analysis report. These activities yield significant data inputs to the technical writers' preparation of the technical publication draft. In addition, Blocks 24 and 25 represent the distribution of these data not only to the writers, but also to the NTIPS data base. Block 26 represents the contractor activity of updating and tailoring of DID's and Specifications to fit the specific requirements of the individual system and/or publication product. This activity is included to provide the contractor with the opportunity to use the knowledge gained in the developing system to shape requirements to provide unique and cost effective solutions to problems. Block 27 represents the activity of writing and editing the TI. Block 28 represents the application of

the QA to the TI Generation phase of TI Development. Block 29 represents the validation process in which the contractor personnel using a draft of the technical publication carry out the assigned maintenance/operation tasks in order to determine the technical accuracy, adequacy, and completeness of the TI content. Block 30 represents a Navy activity supported by the contractor which is similar to the validation process. Verification is carried out by the Navy under operational conditions to determine the accuracy, adequacy, and completeness of the technical information. It is frequently required that a contractor provide training for Navy personnel who will participate in the verification process. This task is represented by Block 31. The verification process has two results: 1) an update and correction of all faults found in the technical adequacy and accuracy of the TI, and 2) to identify weaknesses in the training program and training documentation. These results are represented by Blocks 32 and 36. Thus, both validation done by the contractor, and verification done by the Navy are TI correction processes. While preliminary manuals are made available for the verification process, final camera ready or digitized copy preparation is represented by Block 35 of the diagram. Following the preparation of the master copies of the corrected and updated TI, the process of Replication is carried out as represented by Block 37. Block 38 and 39 represent the distribution of the replicated copy to the User activity or appropriate Shore establishment. Once delivered, the process of error detection by Users continues. As errors are detected and the need for updating the TI is determined, the process of updating is initiated. The processes of detection and update are depicted by Block 42 and 44. The feedback loop leading from Block 44 will be carried as far back into the NTIPS as the correction requires and will be determined on an individual basis.

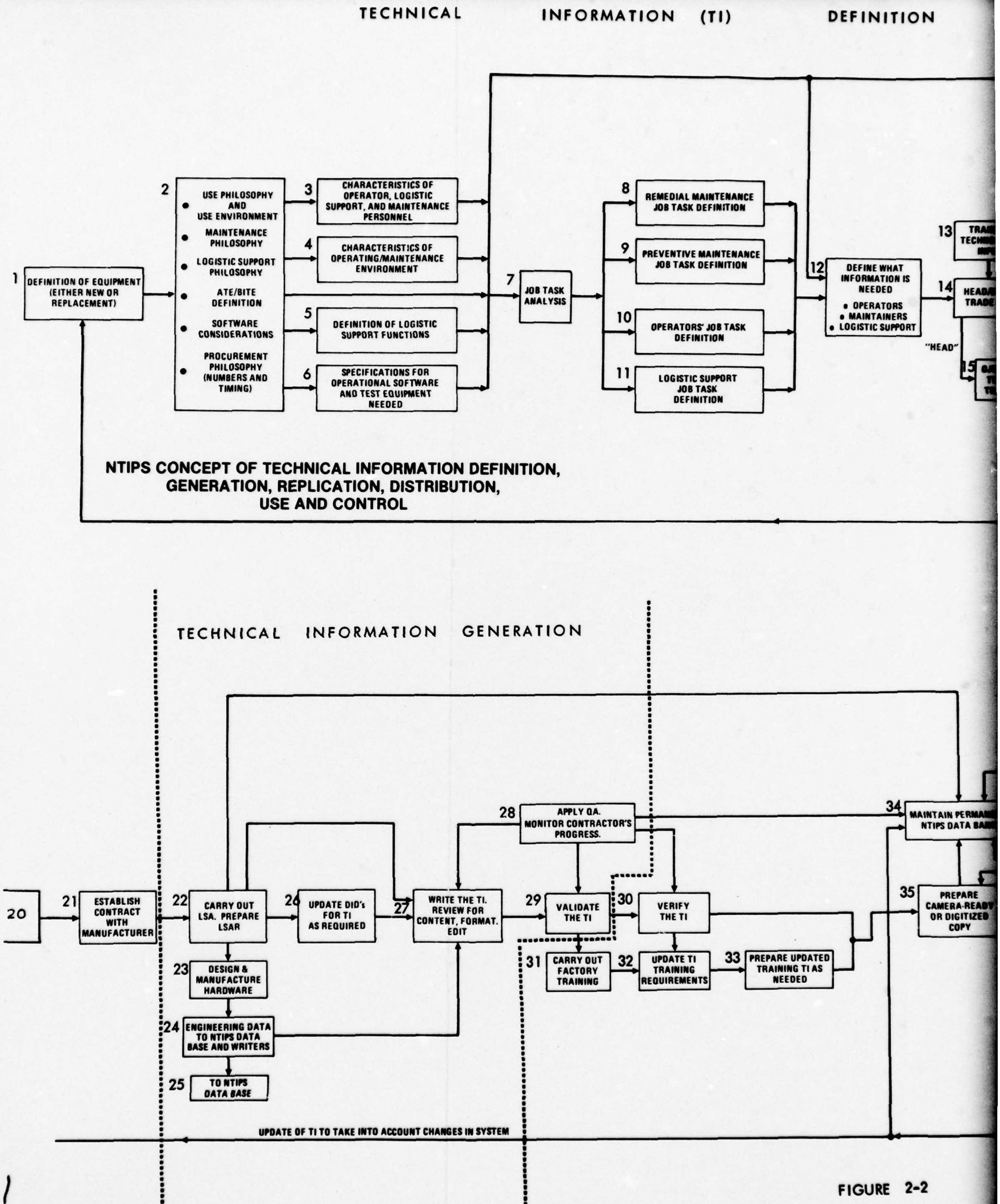
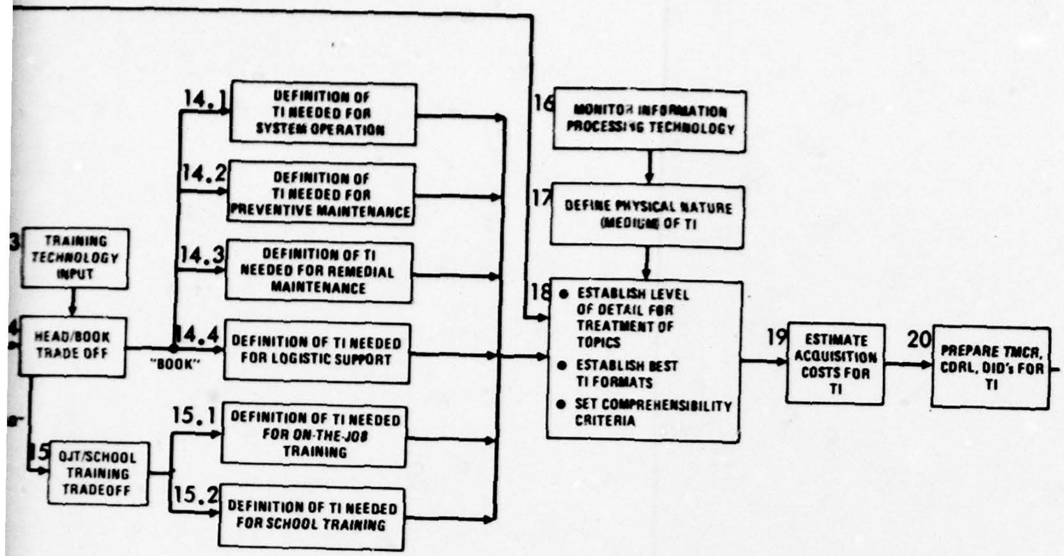
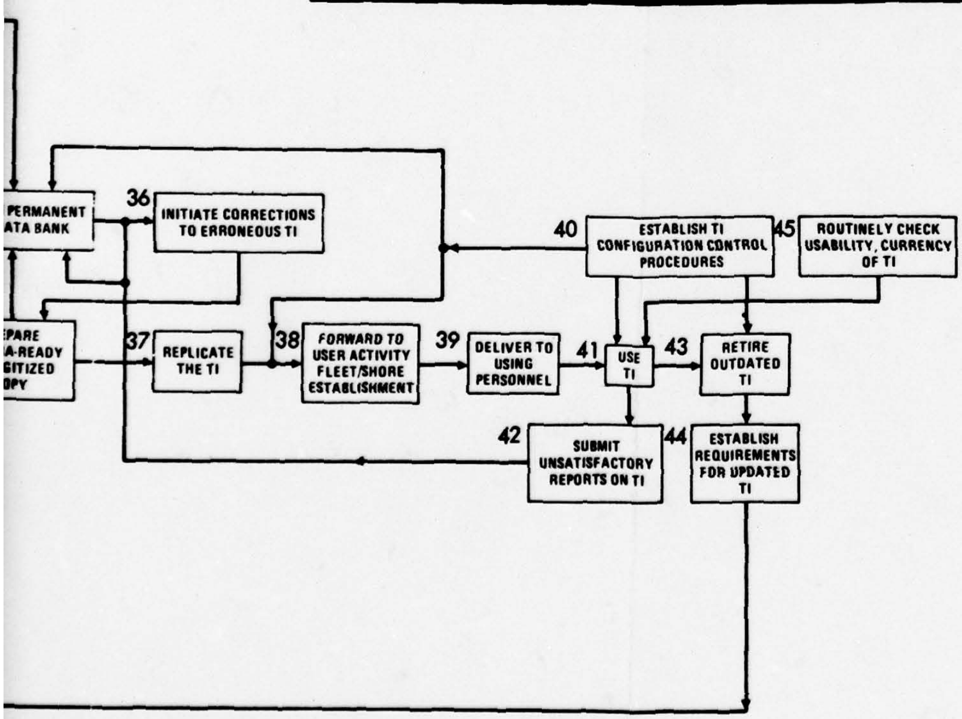

TECHNICAL INFORMATION (TI) DEFINITION
1 DEFINITION OF EQUIPMENT (EITHER NEW OR REPLACEMENT)
2 USE PHILOSOPHY AND USE ENVIRONMENT
MAINTENANCE PHILOSOPHY
LOGISTIC SUPPORT PHILOSOPHY
ATE/BITE DEFINITION
SOFTWARE CONSIDERATIONS
PROCUREMENT PHILOSOPHY (NUMBERS AND TIMING)
3 CHARACTERISTICS OF OPERATOR, LOGISTIC SUPPORT, AND MAINTENANCE PERSONNEL
4 CHARACTERISTICS OF OPERATING/MAINTENANCE ENVIRONMENT
5 DEFINITION OF LOGISTIC SUPPORT FUNCTIONS
6 SPECIFICATIONS FOR OPERATIONAL SOFTWARE AND TEST EQUIPMENT NEEDED
7 JOB TASK ANALYSIS
8 REMEDIAL MAINTENANCE JOB TASK DEFINITION
9 PREVENTIVE MAINTENANCE JOB TASK DEFINITION
10 OPERATORS' JOB TASK DEFINITION
11 LOGISTIC SUPPORT JOB TASK DEFINITION
12 DEFINE WHAT INFORMATION IS NEEDED
OPERATORS
MAINTAINERS
LOGISTIC SUPPORT
13
14
"HEAD"
15
NTIPS CONCEPT OF TECHNICAL INFORMATION DEFINITION, GENERATION, REPLICATION, DISTRIBUTION, USE AND CONTROL
TECHNICAL INFORMATION GENERATION
20
21 ESTABLISH CONTRACT WITH MANUFACTURER
22 CARRY OUT LSA. PREPARE LSAR
23 DESIGN & MANUFACTURE HARDWARE
24 ENGINEERING DATA TO NTIPS DATA BASE AND WRITERS
25 TO NTIPS DATA BASE
26 UPDATE DID's FOR TI AS REQUIRED
27 WRITE THE TI. REVIEW FOR CONTENT, FORMAT. EDIT
28 APPLY QA. MONITOR CONTRACTOR'S PROGRESS.
29 VALIDATE THE TI
30 VERIFY THE TI
31 CARRY OUT FACTORY TRAINING
32 UPDATE TI TRAINING REQUIREMENTS
33 PREPARE UPDATED TRAINING TI AS NEEDED
34
35
UPDATE OF TI TO TAKE INTO ACCOUNT CHANGES IN SYSTEM

FIGURE 2-2



NOTE: This diagram of the NTIPS has been modified by Hageman, Inc. to the following extent:
1) Block numbers inserted
2) The addition of dashed lines to identify phases
3) Titles of Phases



SECTION 3
DETAILED DISCUSSION OF
TI GENERATION

3.1 GENERAL DISCUSSION

In the previous section, Section 2.2, an upper level diagram of the NTIPS was presented and discussed in order to provide a background for a more detailed discussion of the TI Generation phase of NTIPS. The information presented in Section 2 was gleaned from reports and other documents listed in Appendix B of this report, as well as from personal contacts with Navy personnel and industry representatives. Section 3.4, TI Generation Discussion, presents a rather detailed block diagram and discussion of the activities and processes of the TI Generation phase. While this discussion is constrained by the NTIPS requirements, certain assumptions with regard to NTIPS objectives and processes are made which may not fall within the current NTIPS concept. The simplified technical publications paradigm, Figure 3-1, describes some of the assumptions and objectives. The paradigm shows that data is processed according to certain rules by a writer who then synthesizes the data into useable information which after proper training is used by personnel to perform some task on a piece of equipment which results in equipment performance. If the data are valid; the rules are correct; and the writer obeys these rules, interprets the data correctly, and synthesizes well; the assumption is that useable information will result. It is further assumed that adequately trained personnel using good information can then perform tasks on equipment which will result in proper equipment performance. The final measure of the effectiveness of the information and its means of presentation can only be the performance of personnel and the performance of the equipment. Direct testing of the effectiveness of the information under these circumstances is difficult and further compounded by the adequacy of the training of the personnel performing the task. However, it may be assumed that, if the data are incomplete or contain errors, the useability of the information will be reduced and task and equipment performance impaired. If, on the other hand, the data are current, complete, and error-free,

TECHNICAL PUBLICATIONS PARADIGM

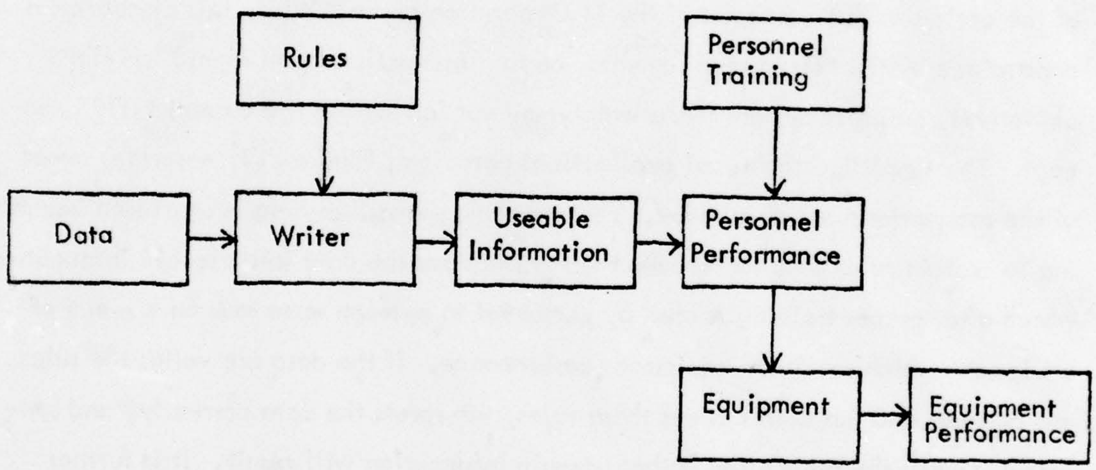


FIGURE 3 - 1

the probability of obtaining useable information is enhanced and as a direct consequence, task and equipment performance are enhanced. By the same token, if the rules provided the writer are clear, easily comprehensible, complete, and correct, the probability of obtaining useable information is enhanced. Of course, the same thing is true of the writer's skills and knowledge which are dependent upon his basic ability and his training. If the writer possesses the skills and knowledge to interpret data properly, and to be guided by the rules, then the probability of obtaining useable information is enhanced. The corollary is that without these skills the writer is less likely to produce useable information. Briefly, bad data, bad rules, or bad writers, cannot be expected to produce anything but bad information; while good data, good rules, and good writers, have a higher probability of achieving an acceptable result. The remaining variable shown in the paradigm which has not been discussed is personnel training. While technical publications personnel cannot be expected to be responsible for training the personnel performing a task, they can be expected to prepare documentation designed specifically for personnel with a known level of training and experience. Once personnel skills and training have been defined, it is the responsibility of technical publications writers to write or prepare documentation suitable for personnel possessing those skills.

TI Generation, unlike TI Definition, is a contractor process and responsibility, and like other contractor processes, should be supported by a well-defined Quality Assurance program. The QA program requirements should be defined by Procurement Specifications and Data Item Descriptions. The TI Generation task, unlike a manufacturing task, is not iterative in the same sense as a machine process. The development of each manual or each page of the manual is a unique human process involving both data interpretation and text synthesis. Regardless of the medium used in the presentation of technical information, human processes and activities are an essential and crucial element in the development of a technical publication.

3.2 HUMAN PROCESSES

Figure 3-2 is an expanded paradigm of the technical publication process and objectives which emphasizes the human activities. Writers and illustrators interpret both the rules and the data and then proceed to synthesize a product. The editor presumably interprets the rules in the same manner as the writer and illustrator and provides a check of the quality of their performance. Validation is accomplished by providing maintenance or operator personnel with a draft of the publication which the Operator/Maintenance personnel then use to perform the required tasks. The task of editors is to verify the adherence of the writer or illustrator to the rules which apply to the product. The task of validation on the other hand, does not test the draft directly, but tests whether or not the task can be performed in a satisfactory manner by Operator/Maintenance personnel. Procedural validation is therefore the first test of the effectiveness of the manual. It is possible for a manual to be prepared in accordance with all the rules, but due to data errors, to describe task requirements that are impossible to carry out. The validation process uses personnel who are presumably representative of the user to test the adequacy of the manual with regard to its intended purpose, i.e., to enable maintenance and operator personnel to perform the desired tasks successfully. Contractor procedural validation of technical publications is an essential "test" of manual effectiveness.

Human processes are not as easily controlled as are machine processes. A machine, once set up, can produce duplicate parts rapidly, efficiently, and accurately. Writers cannot produce words in the same manner. Thus, not only is it more difficult to define the writer's task, but it is also equally difficult to control the quality of his product. Whatever control is achieved must be achieved through the control of human processes. There is a need to establish a mechanism which increases the probability that the interpretation of rules and data is accurately and efficiently carried out. There is a need to insure that the synthesis of text, in accordance with the rules, is also effectively and efficiently implemented. It is also essential that the effectiveness of the processes be checked by procedural validation as part of the TI Generation phase of NTIPS. The contractor must be made responsible for the activities of interpretation, synthesis, and validation. This contractor responsibility must be monitored closely by Quality Assurance personnel if a quality product is to be the result. The quality product in the case of NTIPS is effective operator and maintainer task performance.

HUMAN PROCESSES

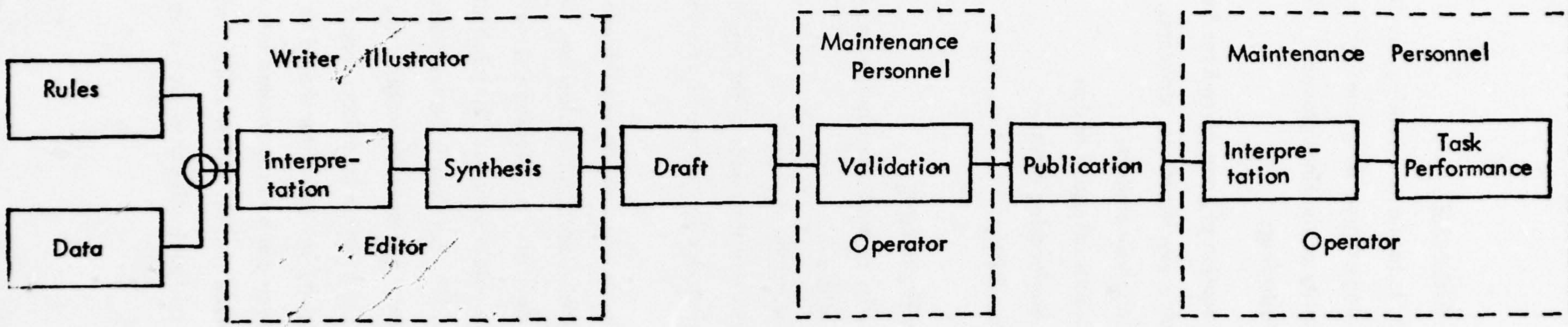


FIGURE 3 - 2

3.3 CONTROL OF HUMAN PROCESSES

Mechanisms for controlling human behavior are training, evaluation, and feedback. The extent and scope of the training program developed by the contractor for his technical writers is crucial to the quality of the final product. Writers/Illustrators should receive training in at least the following:

- The physical location of, and procedures for, acquiring data
- Use of applicable specifications, standards, and DID's
- Utilization of analysis products
- Equipment characteristics and design
- Utilization of engineering reports
    - Maintainability
    - Safety
    - Human Engineering
    - Criticality of equipment to hardware success
- Use of Style Guides
- Vocabulary limitation
- Syntax appropriate to the needs of the product
- Availability of production personnel as a data resource

Continuous evaluation of the writer's performance and intermediate products is essential. It is inefficient to wait for the final product for evaluation. With sophisticated word-processing equipment currently available, all increments, no matter how small, of the final product should be evaluated objectively following initial typing. Objective evaluation of the writer's product, which could easily be handled by word-processing equipment, include: (1) vocabulary use, (2) sentence length, (3) word length, and (4) some syntactical elements, Subjective evaluation by editors should also be carried out concurrently with the objective evaluation, but the editor should be relieved of the tedious task associated with variables which can be incorporated into a word-processing system review of the text. It is emphasized that the writer's first draft of the text material should be evaluated objectively and subjectively in such a way that deficiencies are

specifically identified for him. Flesch counts or other techniques which yield a score for the author's entire product are not an effective means for controlling writer processes.

Feedback is the third mechanism for controlling human behavior. The immediacy of feedback is critical to the effectiveness of that mechanism for controlling behavior. It is therefore emphasized that even the smallest part of the writer's product should receive immediate attention before it is returned. When he turns the draft into the typist, that draft should be processed objectively and returned to him with the objective comments immediately available. Objective processing makes possible preliminary editing of the text by an editor, since a major portion of the tedious and time-consuming mechanical task will be done for him. The mechanism for controlling the writer's performance then consists of effective broad-based training, continuous evaluation, and immediate feedback.

3.4 TI GENERATION DISCUSSION

Technical Information Generation is interpreted to include all essential contractor *activities from the* establishment of a technical publications contract to the completion and submittal of a final manuscript or final documentation presented in some other medium. There are six basic elements or functions which the contractor must be prepared to implement. They are:

(1) Management and Administration
(2) Data Acquisition and Distribution
(3) Analysis
(4) Training
(5) Text Preparation
(6) Illustration Preparation

Three of the above functions are commonly found in industry today, and are in fact organizational elements of the technical publications organization. These are;

management, the writing group, and the illustrations group. The other three functions; data acquisition, analysis, and training, may be carried out implicitly but are not commonly addressed directly through organizational responsibility, planning, or scheduling.

The interrelationships among the TI Generation elements and a detailed description of essential activities is described in the block diagram Figure 3-3, entitled Technical Information Generation. In order to establish a point of reference with NTIPS, the diagram begins with block number 21 entitled Establish Contract of Figure 2-2, and is an expansion of the information contained in Figure 2-2. All of the activities depicted in the diagram should be included explicitly in TI Generation planning and scheduling. Moreover, all activities depicted should be addressed directly and formally in technical publications proposals in order to permit evaluation prior to the establishment of a contract. While the diagram is functionally oriented, it is implicit that the functions should be represented by contractor organizational elements. In the following discussion, when convenient, organizational responsibilities may address the organizational element or group responsibility directly.

3.4.1 DESCRIPTION OF THE DIAGRAM

The Block Diagram of the TI Generation phase of NTIPS is supported by a narrative explanation which describes the activity associated with each of the block titles. These paragraphs are listed by block number for reference. The block diagram not only identifies the activity, but also indicates a rough sequence and the interrelation among the activities depicted by the block titles. The diagram is read from left to right, and therefore, arrows are not used.

The symbols used in the connecting structure for the blocks represent the three logical operations: AND, non-exclusive OR, and the exclusive OR.

(a) The Symbol ⦶ indicates the logical AND, which means both (or all) are necessary

(b) The Symbol indicates non-exclusive OR, which means one or both (or any) may obtain

(c) The Symbol indicates the exclusive OR, which means one or the other but not both (or all) may obtain

3.4.2 EXPLANATION OF THE BLOCK DIAGRAM

The following is a narrative description of the block diagram Figure 3-3 entitled "Technical Information Generation". While the level of detail included in the description below may be greater than necessary for an understanding of the TI Generation process, it is not too great for determining which processes are amenable to QA surveillance.

3.4.2.1 BLOCK NO. 1 - INITIATE IMPLEMENTATION OF THE PROGRAM PLAN

The first step following the award of the contract is to initiate the implementation of the approved Program Plan in accordance with the schedule enclosed in that plan.

3.4.2.2 BLOCK NO. 2 - ACTIVATE ORGANIZATIONAL ELEMENTS

An essential first step in implementing the Program Plan is to activate the organizational elements required by the plan. It is presumed that the first element to be activated will be Management and Administration.

3.4.2.3 BLOCK NO. 3 - MANAGEMENT AND ADMINISTRATION

Management and Administration responsibilities begin the first day following contract award and do not end until the final product contracted for has been accepted and delivered. In order to sustain effective management throughout the development of TI products, responsibilities and authority for each of the elements within the technical publications group must be clearly defined and specified.

3.4.2.4 BLOCK NO. 3.1 - SCHEDULES AND PLANNING

It is the responsibility of the management and administrative group to develop schedules for both final and intermediate products for every deliverable specified in the contract.

Schedules must be compatible with, and are dependent upon, the hardware development schedule for which the technical publication are being prepared. Planning for analysis, writer and illustrator training, and writer assignment, must be compatible with information availability which in turn is contingent upon the basic equipment production schedule. Scheduling and planning carried out for the development of technical publication products must reflect this compatibility to ensure the delivery of TI concurrent with the hardware.

3.4.2.5 BLOCK NO. 3.2 - PERSONNEL REQUIREMENTS AND ASSIGNMENTS

Following the development of TI schedules, the management and administration group should identify personnel requirements and begin to make personnel assignments in accordance with the predicted needs of the program.

3.4.2.6 BLOCK NO. 3.3 - FACILITIES REQUIREMENTS AND ACQUISITION

It is the task of management to identify facility requirements, to develop a realistic acquisition schedule, and to initiate those actions necessary to acquire the needed facilities.

3.4.2.7 BLOCK NO. 3.4 - INTEGRATE AND COORDINATE THE ACTIVITIES OF ALL ELEMENTS OF THE TECHNICAL PUBLICATIONS ORGANIZATION

If manpower and facilities are to be used effectively, their utilization must be coordinated and integrated not only across organizational elements, but also within elements.

3.4.2.8 BLOCK NO. 3.5 - MONITOR PERFORMANCE

It is also management's responsibility to monitor and review the performance of the various production elements of the technical publications organization in order to insure that a quality product is delivered as scheduled. Management must have well developed means and mechanisms for monitoring performance and intermediate products in order to insure final delivery.

3.4.2.9 BLOCK NO. 3.6 - ADJUST SCHEDULE AND MAN/LOADING AS REQUIRED

Since it is unlikely that any hardware development program will be implemented as planned, the technical publications organization management must be responsive to the changing hardware schedules by adjusting man/loading and schedules in order to avoid inefficient use of resources and high periodic work loads. If the hardware system delivery date is delayed by two months, the data acquisition for that system will also be delayed. Management must either reassign personnel or pay the price of lost man-hours. Lost man-hours early in the program can only lead to peak loads and premium pay as the delivery dates approach. Constant shifting and adjusting of personnel and assignments in accordance with the hardware program are essential if wasted man-hours and premium pay are to be avoided.

3.4.2.10 BLOCK NO. 3.7 - MEET PRODUCT DELIVERY DATE

The major goal of management is to deliver a quality product as scheduled. This does not imply that the initial schedule is necessarily the one to be met. It is the adjusted schedule based upon hardware development that is the critical date.

3.4.2.11 BLOCK NO. 4 - DATA ACQUISITION AND DISTRIBUTION

Data are the raw material of the Technical Information Generation process. Without a formal effective data acquisition and distribution system, effective technical publications cannot be assured. Data acquisition is of prime importance since it provides the basis for the publication content. The process should be formalized and systemitized; and the significance reflected in the technical publications organization.

3.4.2.12 BLOCK NO. 4.1 - PREPARE DATA ACQUISITION SCHEDULE

Data requirements for each technical publication product should be prepared and availability dates identified on a schedule in order to ensure the earliest possible acquisition of each and every required datum.

3.4.2.13 BLOCK NO. 4.2 - DEFINE ACQUISITION AND DISTRIBUTION PROCEDURES

Data are of no use to a writer unless they are available to him. Thus, formal data-acquisition and data distribution procedures should be established by the data-acquisition group. The users of the data should be informed and instructed in the standard acquisition and distribution procedures.

3.4.2.14 BLOCK NO. 4.3 - DEFINE FACILITY REQUIREMENTS AND ACQUIRE

In the event that planning indicates additional facilities are required, it is the responsibility of this group to take the necessary action to acquire the needed facilities.

3.4.2.15 BLOCK NO. 4.4 - ACQUIRE DATA AND DISTRIBUTE

Once the procedures are implemented and facilities are available for data distribution, it is the responsibility of this group to both acquire and distribute the data as scheduled. When it is cost effective, this group may notify users of data availability and location in lieu of acquisition and distribution.

3.4.2.16 BLOCK NO. 4.5 - MAINTAIN LOGS AND FILE

It is the responsibility of the data acquisition and distribution group to maintain logs of the physical location of data which are not and will not be physically co-located with the group. Data availability and physical location must be recorded for co-located and non co-located data.

3.4.2.17 BLOCK NO. 5 - ANALYSIS

Analyses, which are implemented by the Navy during the TI Definition phase of NTIPS, should be provided to the contractor for his review and to enable the contractor to identify additional analysis requirements.

3.4.2.18 BLOCK NO. 5.1 - REVIEW ALL PRELIMINARY ANALYSES

It is the contractor's responsibility to review all preliminary analyses implemented by the Navy during the TI Definition phase of the program.

3.4.2.19 BLOCK NO. 5.2 - ITERATE AND UPDATE ALL ANALYSIS AS REQUIRED

Since it is the contractor who develops the detailed information and detailed data needed to carry out a complete and detailed analysis of the technical publications requirements, the contractor should iterate and update the analysis carried out by the Navy in the TI Definition phase of the program. Contractor analyses should be carried to the task level.

3.4.2.20 BLOCK NO. 5.3 - PREPARE PRELIMINARY WRITER/ILLUSTRATOR TRAINING REQUIREMENTS

One of the by-products of the analyses should be the identification of writer and illustrator preliminary training requirements. When completed in preliminary form, these requirements should be turned over to the training group for development and finalization of training plans.

3.4.2.21 BLOCK NO. 5.4 - MODIFY SPECIFICATION AND DID REQUIREMENTS AS INDICATED

The analysis group should also be responsible for establishing modified specification and DID requirements when indicated by the results of the analysis. The contract must of course be suitably modified as required to formalize these changes.

3.4.2.22 BLOCK NO. 5.5 - REVIEW TRAINING PLANS

The analysts responsible for preparing the preliminary writer and illustrator training requirements should review the final training plan prepared by the training group for compliance with the requirement described in Block 5.3 above.

3.4.2.23 BLOCK NO. 5.6 - ITERATE ANALYSES AS REQUIRED

TI analyses should be repeated in response to engineering changes when such changes are approved.

3.4.2.24 BLOCK NO. 5.7 - REVISE REQUIREMENTS AS NECESSARY

When hardware changes require an analysis iteration, the potential for revision to specifications and DID's must also be evaluated and further contractual changes made when warranted.

3.4.2.25 BLOCK NO. 6 - TRAINING

Since training is the primary means for controlling the quality of writer data interpretation and writer and illustrator synthesis, it is impossible to place too much emphasis on this element of the Technical Information Generation phase of NTIPS. Training is the primary technique for achieving a high quality final product in terms of technical content, completeness, and accuracy.

3.4.2.26 BLOCK NO. 6.1 - REVIEW PRELIMINARY TRAINING REQUIREMENTS

The training group will develop detailed training requirements for writers and illustrators based on the preliminary training requirements resulting from analyses.

3.4.2.27 BLOCK NO. 6.2 - PREPARE TRAINING PLAN AND SCHEDULE

A detailed plan and schedule should be prepared which are compatible with the hardware development and technical publication schedules. The schedules developed for training must be compatible with product-need dates.

3.4.2.28 BLOCK NO. 6.3 - PREPARE CURRICULA AND CERTIFICATION PROCEDURES

Following development of the training plan and schedule the training group should develop detailed curricula and certification procedures. Writer certification is a means of controlling the quality of training and assessing the effectiveness of training. Certification is construed as an essential ingredient of the Technical Information Generation phase of NTIPS.

3.4.2.29 BLOCK NO. 6.4 - IMPLEMENT TRAINING

This block is self-explanatory.

3.4.2.30 BLOCK NO. 6.5 - CERTIFY WRITERS AND ILLUSTRATORS

Following the completion of training, writers and illustrators will be certified <u>for the particular task</u> to which they are assigned. Certification of writers and illustrators should be a formal process. Editors will be certified as writers for each area of editing responsibility.

3.4.2.31 BLOCK NO. 6.6 - REVISE TRAINING AND CERTIFICATION AS REQUIRED

Continuous evaluation of writer and illustrator certification procedures should be carried out until there is clear evidence that both the training and certification procedures are effective in producing a quality product.

3.4.2.32 BLOCK NO. 6.7 - IMPLEMENT ADDITIONAL TRAINING AS REQUIRED

The evaluation process may dictate a revision in the training or certification procedures and also identify areas where additional training is required. When such areas are identified, additional training should be implemented by the contractor.

3.4.2.33 BLOCK NO. 7 - WRITER

Writers, along with the illustrators (See Block No. 8) are the production personnel of the Technical Publications program. All other TI Generation activities support this element.

3.4.2.34 BLOCK NO. 7.1 - PREPARE SCHEDULE FOR EACH PRODUCT

Each writer should be provided a detailed schedule for each product for which he has responsibility. This schedule should include the writer's training schedule, the availability of analysis results, and the availability of other data. Each writer will then be fully aware of the material inputs required for his effort and immediately detect missing materials (data) and other potential problems.

3.4.2.35 BLOCK NO. 7.2 - TRAINING

Each writer should receive training (as cited in Block 6.4) in organizational procedures, data-acquisition procedures, the availability of analyses results, the detailed formal requirements of his product, hardware design, and hardware availability schedules. Editors will be trained as writers in each area of editing responsibility.

3.4.2.36 BLOCK NO. 7.3 - CERTIFICATION

The procedure for certification of a writer (as cited in Block 6.5) should provide evidence of satisfactory completion of the training program as evidence of his ability to perform his assigned task. Editors will be certified as writers in each area of editing responsibility.

3.4.2.37 BLOCK NO. 7.4 - ACQUIRE DATA AND KEEP LOG

It should be the responsibility of each individual writer to keep a log of his data requirements and acquisitions including both material and personnel contacts. The log should reflect the completion of intermediate data products, draft reviews, and draft validation.

3.4.2.38 BLOCK NO. 7.5 - PREPARE TEXT AND ILLUSTRATION REQUIREMENTS

It is the writer's task to prepare text and to identify illustration requirements.

3.4.2.39 BLOCK NO. 7.6 - PREPARE TEXT

The writer should prepare his text and update his log on a weekly basis.

3.4.2.40 BLOCK NO. 7.7 - ASSEMBLE DRAFT FOR EDITING

It is the writer's responsibility to assemble text and illustrations into a draft suitable for editing.

3.4.2.41 BLOCK NO. 7.8 - COORDINATE VALIDATION PROCESSES AND SCHEDULES

Validation is a QA process which must be planned and scheduled by the writer (and illustrator) or he must at least assist the QA personnel in validation planning and scheduling.

3.4.2.42 BLOCK NO. 7.9 - SUPPORT VALIDATION

When the writer has planned and scheduled (or assisted the QA personnel in planning and scheduling) the validation process, he will support the implementation of the validation process as indicated in the validation plan.

3.4.2.43 BLOCK NO. 7.10 - REVISE AND REVALIDATE AS REQUIRED

Following initial validation, the draft (both text and illustrations) will be revised as required and revalidated if necessary.

3.4.2.44 BLOCK NO. 7.11 - SUBMIT FINAL DRAFT

Following the post-validation revision of the draft, the final draft (including illustrations) in the required medium will be submitted to the Navy for verification.

3.4.2.45 BLOCK NO. 7.12 - SUPPORT VERIFICATION PLAN PREPARATION

The contractor will prepare a verification plan based on Navy requirements in order to assist the Navy in planning. The writer will support the effort of developing the verification plan.

3.4.2.46 BLOCK NO. 7.13 - SUPPORT VERIFICATION AS REQUIRED

The Navy may require support during the verification process. It will be the writer's responsibility to support the Navy as required during verification.

3.4.2.47 BLOCK NO. 7.14 - REVISE AS REQUIRED

Following verification, it is the writer's responsibility to revise text and requirements for illustrations as indicated by the results of the verification.

3.4.2.48 BLOCK NO. 8 - ILLUSTRATOR

The illustrator is the other "production" person in the TI Generation process along with the writer. The writer takes the lead in preparing the text and assembling the completed draft, and the illustrator must meet the writer's requirements.

3.4.2.49 BLOCK NO. 8.1 - PREPARE SCHEDULE FOR EACH PRODUCT

In order for illustrations to be prepared efficiently, the efforts and assignments of each illustrator should be scheduled in order to be compatible with the overall technical publications organization.

3.4.2.50 BLOCK NO. 8.2 - TRAINING

Illustrators should receive training in the same manner and in the same areas as the writers.

3.4.2.51 BLOCK NO. 8.3 - CERTIFICATION

Illustrators should be certified under the same program as the writers.

3.4.2.52 BLOCK NO. 8.4 - ACQUIRE DATA AS REQUIRED

In the case of the illustrators, the detailed illustration requirements are provided by the writers (Block 7.5) and form an essential part of the illustrators' data needs. The same procedures which are used to provide the raw materials for writers should be used to provide illustrators with their data needs.

3.4.2.53 BLOCK NO. 8.5 - PREPARE ILLUSTRATIONS

This block is self-explanatory.

3.4.2.54 BLOCK NO. 8.6 - SUPPORT VALIDATION

Illustrators as well as writers may be required to support the validation program. If validation support is required, it should be scheduled.

3.4.2.55 BLOCK NO. 8.7 - REVISE ILLUSTRATIONS AS REQUIRED

Following the validation of the technical publication, the illustrator will revise his illustrations as required.

3.4.2.56 BLOCK NO. 8.8 - SUPPORT VERIFICATION

Illustrators as well as writers may be required by the Navy to support verification.

3.4.2.57 BLOCK NO. 8.9 - REVISE AS REQUIRED.

Following verification, the illustrator will revise the illustrations as indicated by the results of the verification.

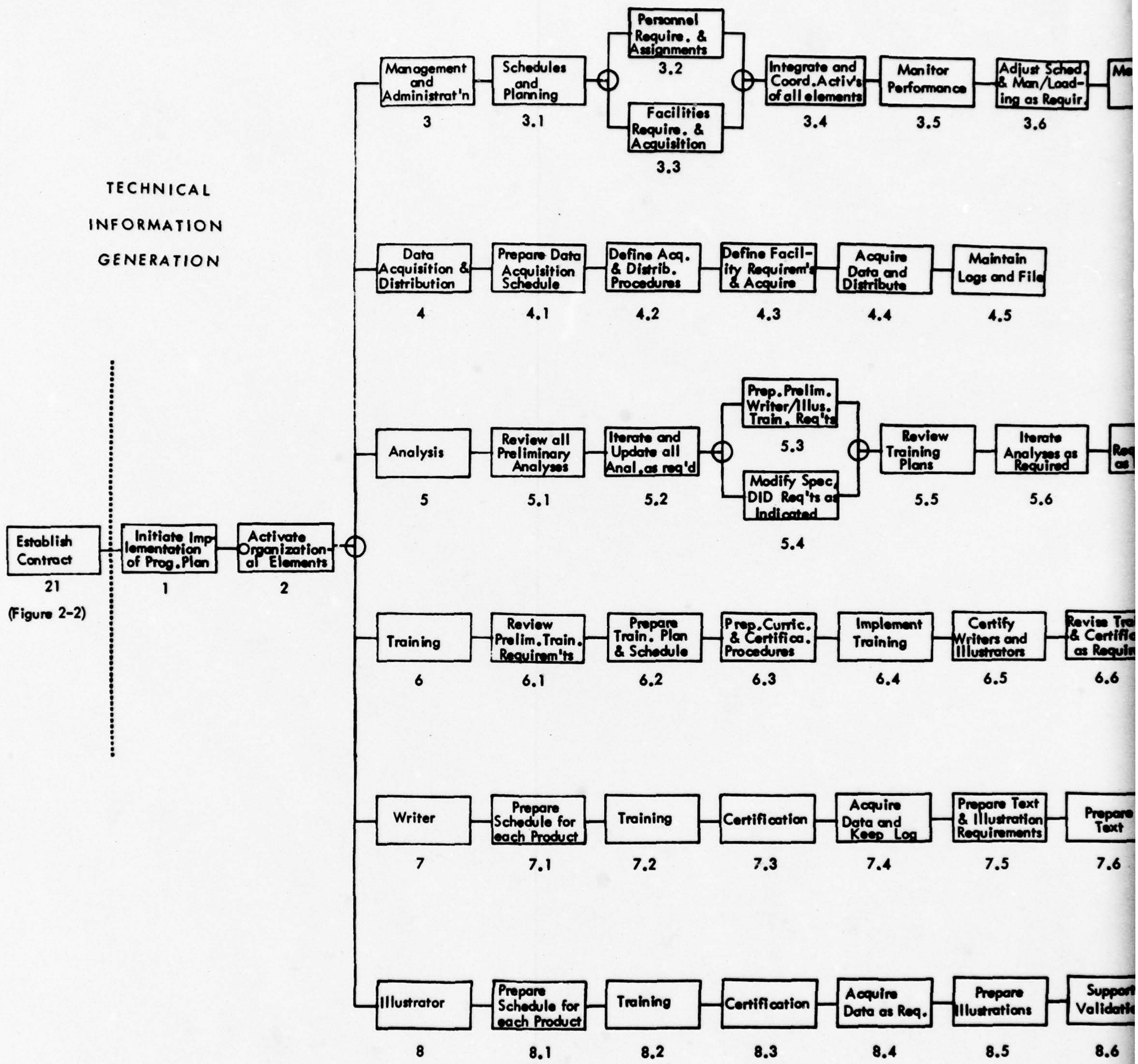
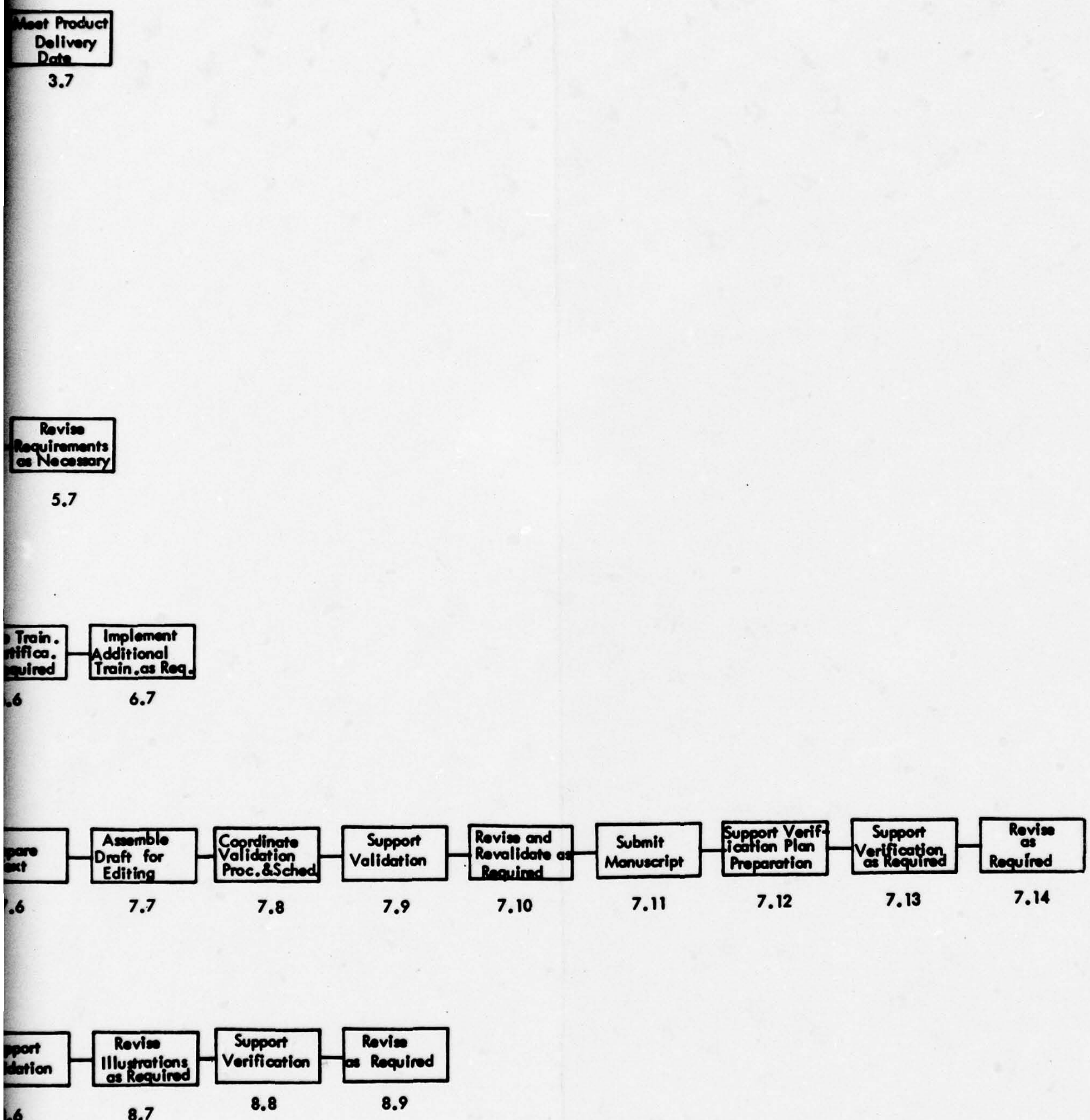

TECHNICAL
INFORMATION
GENERATION
Establish Contract
21
(Figure 2-2)
Initiate Implementation of Prog. Plan
1
Activate Organizational Elements
2
Management and Administrat'n
3
Schedules and Planning
3.1
Personnel Require. & Assignments
3.2
Facilities Require. & Acquisition
3.3
Integrate and Coord. Activ's of all elements
3.4
Monitor Performance
3.5
Adjust Sched. & Man/Loading as Requir.
3.6
Data Acquisition & Distribution
4
Prepare Data Acquisition Schedule
4.1
Define Acq. & Distrib. Procedures
4.2
Define Facility Requirem's & Acquire
4.3
Acquire Data and Distribute
4.4
Maintain Logs and File
4.5
Analysis
5
Review all Preliminary Analyses
5.1
Iterate and Update all Anal. as req'd
5.2
Prep. Prelim. Writer/Illus. Train. Req'ts
5.3
Modify Spec. DID Req'ts as indicated
5.4
Review Training Plans
5.5
Iterate Analyses as Required
5.6
Training
6
Review Prelim. Train. Requirem'ts
6.1
Prepare Train. Plan & Schedule
6.2
Prep. Curric. & Certifica. Procedures
6.3
Implement Training
6.4
Certify Writers and Illustrators
6.5
6.6
Writer
7
Prepare Schedule for each Product
7.1
Training
7.2
Certification
7.3
Acquire Data and Keep Log
7.4
Prepare Text & Illustration Requirements
7.5
Prepare Text
7.6
Illustrator
8
Prepare Schedule for each Product
8.1
Training
8.2
Certification
8.3
Acquire Data as Req.
8.4
Prepare Illustrations
8.5
8.6

FIGURE 3-3


Meet Product Delivery Date
3.7
Revise Requirements as Necessary
5.7
Implement Additional Train.as Req.
6.7
Assemble Draft for Editing
7.7
Coordinate Validation Proc.&Sched.
7.8
Support Validation
7.9
Revise and Revalidate as Required
7.10
Submit Manuscript
7.11
Support Verification Plan Preparation
7.12
Support Verification as Required
7.13
Revise as Required
7.14
Revise Illustrations as Required
8.7
Support Verification
8.8
Revise as Required
8.9

SECTION 4
QUALITY ASSURANCE REQUIREMENTS

4.1 GENERAL DISCUSSION

The Navy has experienced difficulty in obtaining high quality Technical Information on a timely basis, even when adequate specifications have been established. This problem arises as a consequence of applying QA techniques too late in the weapon-system acquisition process. It has been traditional to apply QA to Technical Information (TI) development products, beginning with drafts of the final documents. Redistribution of QA efforts is needed, beginning with audits of the completeness and quality of raw data upon which the documents will be based.

The current Navy QA program is unmanageable. The Navy does not have the resources to fully audit the total product from the various contractors. Accordingly, the approach to QA expressed by this report de-emphasizes the current Navy and contractor QA procedures of monitoring documents and products, and shifts a major portion of the effort to auditing the process of developing TI. The contractor should assure the Navy that the TI development process is being done correctly, and as a result, that a reasonable probability exists that the output will be adequate. Figure 4-1 diagrams a proposed three-tiered process with emphasis on the front end. Navy QA personnel audit the contractor's QA personnel, who in turn, monitor the TI development generation process. Figure 4-2 depicts the current QA program whose emphasis is on editing documents, with the major portion of the effort spent on validation and verification of the product. A hardware system contractor currently provides approximately one QA man for twenty writers. The Navy monitors the contractor QA program with about the same ratio of personnel. The method suggested in this report does not increase this ratio for auditing the proposed QA program, but rather provides for more effective and efficient use of these personnel.

With greater emphasis of the customer and contractor QA on the earlier phases of the development of the TI, indications of the expected quality of the TI can be formulated

PROPOSED QUALITY ASSURANCE PROCESS

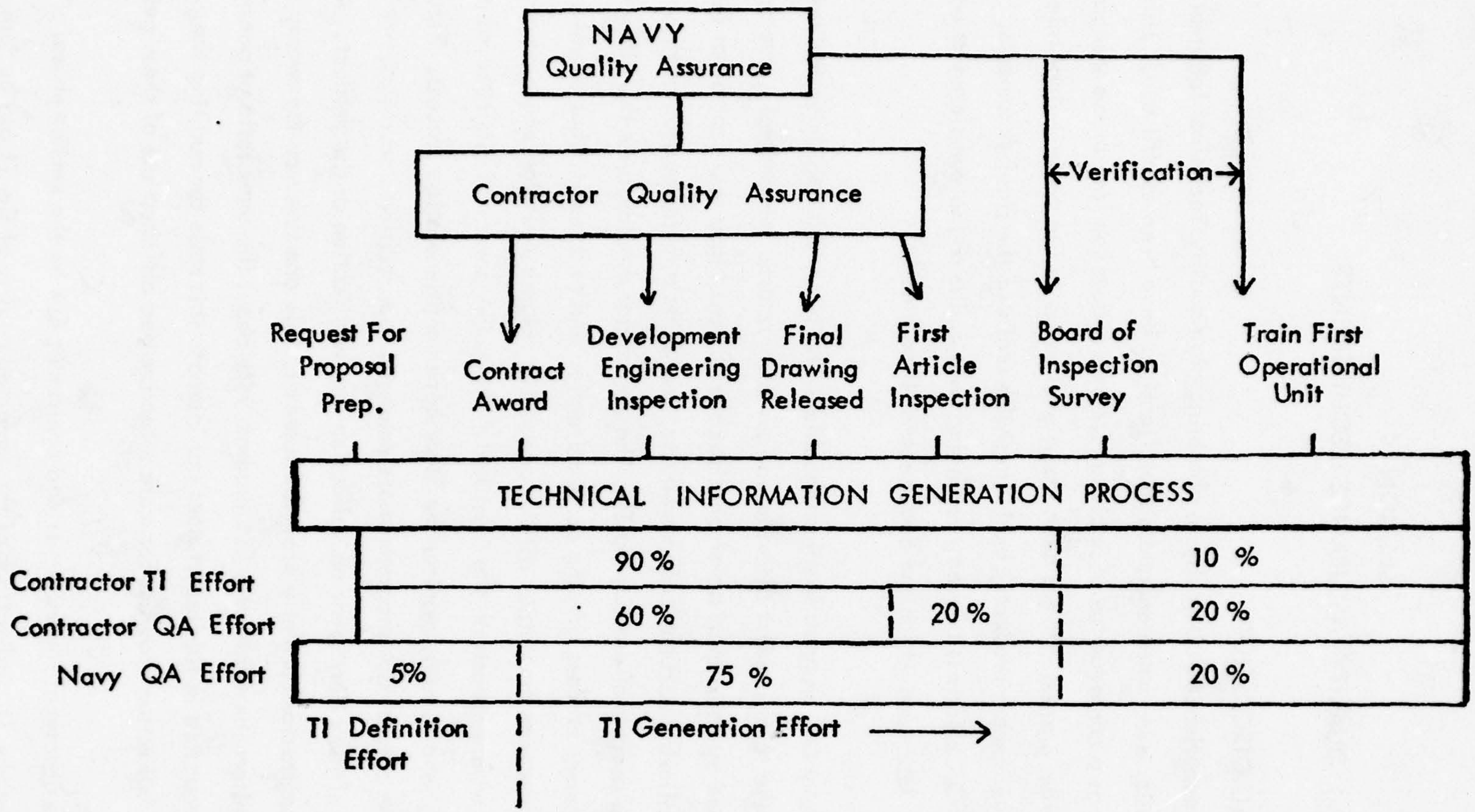


FIGURE 4-1

CURRENT QUALITY ASSURANCE PROCESS

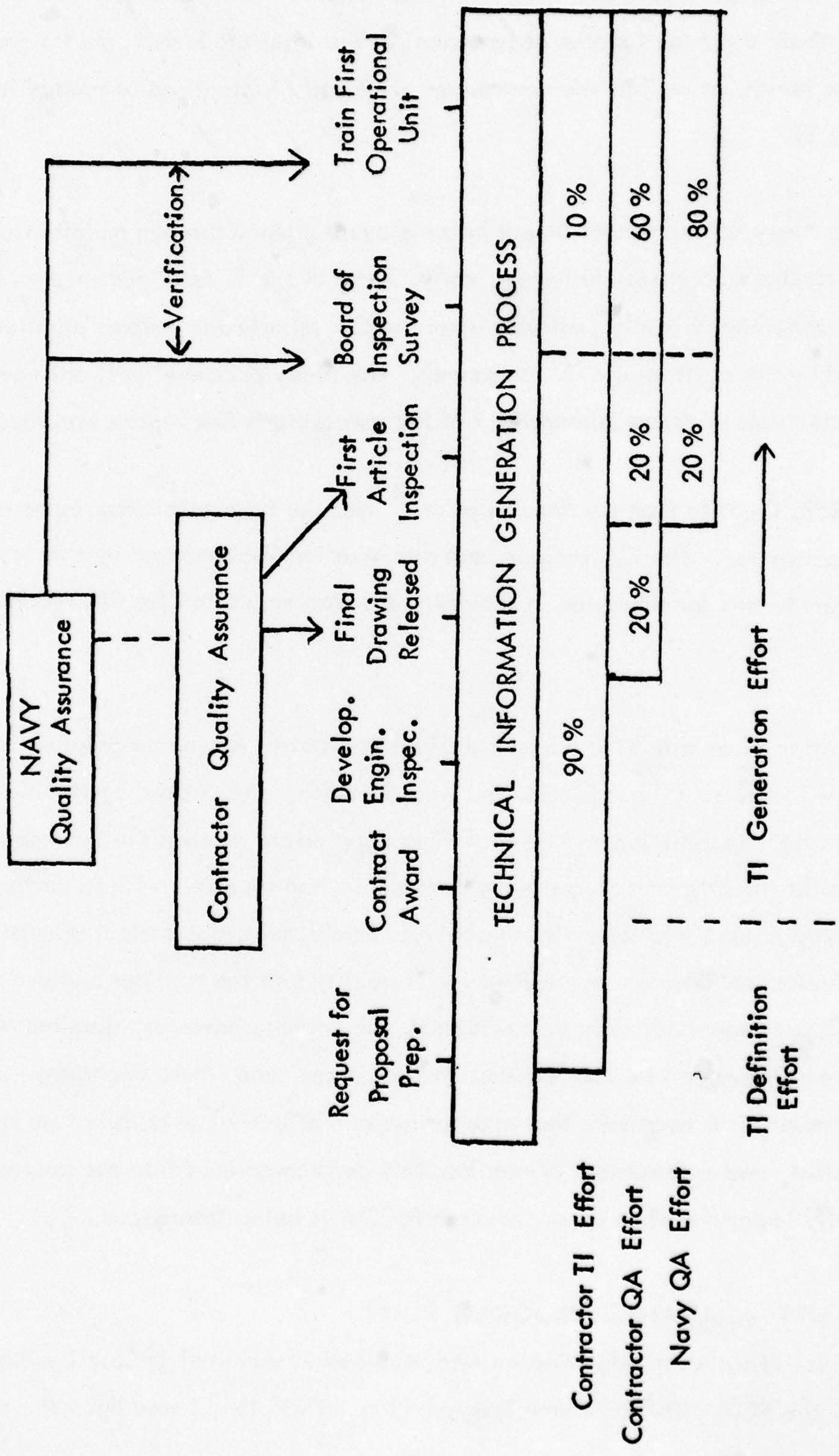


FIGURE 4-2

and a reduced sampling rate can be used in later phases with greater confidence. This would eliminate the peak loading of personnel at the later production phases and would provide the Navy, as well as the contractor, with early indications of production problems of the TI.

So that the Navy QA personnel do not become overburdened through maintaining cognizance of the contractor's activities during the early phases of the TI development process, the Navy QA personnel will rely primarily upon the QA reports and records supplied and maintained by the contractor's QA personnel. The Navy personnel will only perform sample inspections to assure authenticity of the contractor's QA reports and records.

MIL-Q-9858, Quality Program Requirements,[4] must be an explicit requirement imposed upon the contractor. The QA program and organization implemented by the contractor must conform to this specification in providing the documentation for QA reports and records.

Implementation of an effective and economical TI Quality Assurance program is dependent upon two factors: (1) communicating what is needed and desired by the Navy to the contractor and his suppliers, and (2) providing appropriate mechanisms for management and control of the program. Most Navy contractors and suppliers wish to perform well and to maintain good relations with the Navy. Establishment of a clear understanding by all parties as to their responsibilities for TI quality and the methods and procedures to be employed should normally be sufficient. Sometimes, however, disputes might arise between Navy and its contractors. In such cases, and more importantly, to forestall such cases, it is necessary that appropriate and effective mechanisms for management, control, and enforcement of requirements be incorporated into the contract. This is especially important when a new concept for QA is being introduced.

4.2 QUALITY ASSURANCE PROGRAM PLAN

The principal vehicle for achieving an effective and economical TI Quality Assurance program is the TI Quality Assurance Program Plan. This plan, based upon the concepts

and philosophy of MIL-Q-9858, Quality Program Requirements,[4] should be developed during the proposal phase by the contractor in accordance with detailed, specific instructions of a Data Item Description (DID) prepared for this purpose. This DID should be incorporated into the Request for Proposal (RFP) package. Each bidder should be instructed to submit the plan with the proposal. The RFP should make it clear that upon contract award, the plan, as modified in accordance with agreements reached during contract negotiations, is to be incorporated into the contract and is to become the implementing document for the program. This may be achieved effectively by preparing the Program Plan in performance specification format. It should also be understood that the proposed TI Quality Assurance program is subject to disapproval by the Navy whenever the contractor's proposed procedures do not offer a high probability that they will accomplish their objectives. The Navy, at its option, may furnish written notice of the acceptance or disapproval of the contractor's proposed TI Quality Assurance Program Plan.

4.2.1 GENERAL TI QUALITY ASSURANCE PROGRAM REQUIREMENTS

All TI development processes, products, and services under the contract, whether developed, produced, or performed by the contractor or its subcontractors, suppliers, or consultants, should be controlled at all points necessary to ensure conformance to contractual requirements, including the requirements of the approved Plan. The program should provide for the prevention or ready detection of discrepancies or deficiencies at any stage of the TI development program and should provide for timely and positive corrective action. The contractor should be required to make objective evidence of quality conformance readily available to the Navy representative.

The authority and responsibility of those in charge of TI planning, development, production, testing, and inspection of quality should be clearly stated in the Plan. The program should include effective control of purchased materials and subcontracted work.

4.2.2 TI QUALITY ASSURANCE PROGRAM MANAGEMENT

Effective management for TI Quality Assurance should be clearly established and maintained by the contractor. Personnel performing TI Quality Assurance functions should have sufficient, well-defined responsibility and authority, and the organizational freedom needed to identify and evaluate TI quality problems and to initiate, recommend, or provide solutions. The contractor's Management personnel should be required to review the status and adequacy of the TI Quality Assurance program on a regular basis.

The contractor should be required to maintain and use any records or data essential to the economical and effective operation of the TI Quality Assurance program. These records should be made readily available for review by the Navy Representative and copies of individual records or data should be furnished by the contractor upon request. Records are considered one of the principal forms of objective evidence of quality. The TI Quality Assurance program should employ methods and procedures for insuring that records are complete, accurate, and reliable. Records of discrepancies, deficiencies, and corrective actions taken or planned should be established and maintained by the contractor. As a minimum, these records should indicate the number and nature of observations made by the contractor's TI Quality Assurance personnel, together with the number and types of deficiencies found. The contractor should provide detailed record-keeping procedures employing, as appropriate, available QA discrepancy-reporting systems or adaptations thereof. The QA program should provide for the analysis and use of these records as a basis for management action. Summary reports of these records and analyses of trends in TI development processes, or performance of work to prevent further occurrences of deficiencies, should be submitted periodically to the Navy in accordance with the CDRL.

The contractor should be made responsible for QA of TI processes and products acquired from subcontractors and suppliers. The contractor must be required to employ appropriate measures to ensure that each subcontractor maintains the required levels of quality. The contractor's TI Quality Assurance personnel should establish and maintain surveillance over subcontractors at all levels to insure satisfactory performance of QA tasks

and to insure required levels of quality in the TI processes and products. The contractor should be required to schedule and conduct on-site surveys, when necessary, to insure compliance with quality program requirements. Criteria for survey performance should be based upon criticality or complexity of items of TI being procured, known problems or difficulties, and quality history.

4.3 TWO PHASE PROGRAM

The QA inspection criteria will vary with the TI material and products being inspected. In the initial phases of development, the quality of a product is predicted by "indicators"; or perhaps more precisely, the indicators provide notice of impending quality or schedule difficulties of a TI production. The second phase relies upon inspection of specific quality characteristics of the intermediate and final TI products. Consequently, the QA program consists of two phases.

A discussion of statistical methods of sampling to ensure the quality level of the TI is also presented. The statistical procedures can be used in conjunction with both phases and both types of inspection criteria.

4.3.1 QUALITY ASSURANCE INDICATORS

The QA indicators can be used to the greatest advantage during the early phases of the TI development. The early phases produce no inspectable product, but rather involve various activities that are crucial to the successful development of the TI. The performance and course of these activities are tracked by the QA indicators. Though these indicators are essential in the early development of the TI, they should also prove of value in tracking the progress of the TI development through the later stages, where additional inspections of the products are performed.

Certain administrative, analysis, data-acquisition, and data-utilization tasks must be performed so that accurate, useful and timely TI can be generated. Assurance that these tasks are performed on a timely basis serves as an early indication of the timeliness and quality of the final TI product. Thus, the tracking and recording of the

performance of these tasks provide the quality indicators. Contractor QA personnel will not be required to monitor all the TI development through each step, but will use sampling techniques to insure at a sufficient confidence level that each TI development is progressing at a high quality level. As indicated in earlier discussions, Navy QA personnel will then sample the contractor QA records to ensure compliance to the system.

No new processes for the TI development are suggested by the incorporation of the QA indicators. However, additional forms and record-keeping will be required by the technical writer. This additional record-keeping need not be a burden to the writer. On the contrary, proper formulation of the record forms will provide the writer a useful guide and schedule for his development of the TI. Further, the formalization of a data-management program will establish a ready means for the writer to obtain required data and will decrease time the writer must spend in search of the data. QA personnel requirements will be increased in the early phases relative to current requirements during these phases; however, the QA requirements in the later phases should be reduced with a possible overall net decrease in personnel requirements.

QA personnel will be expected primarily to determine whether the administrative, analytical, data-acquisition, and data-utilization tasks have been performed and whether the performance of these tasks has been within schedule. The QA personnel will not be expected to be able to judge the accuracy or quality of the results of these tasks. There are no measurable characteristics to determine such accuracy or quality. For example, in the data-acquisition task, the quality of the data must be assumed to be accurate if the material represents the latest release, and consequently the only criterion for inspection is whether the data were obtained within schedule and whether the data are current and complete. Further, it is not the responsibility of the QA personnel to ascertain the accuracy of analysis results, (e.g., from a User-Data Match or a Head/Book Trade-off), but rather to insure that the results from such analyses are based on the most recent revision of available data and are complete within the scheduled time period.

4.3.2 PRODUCT INSPECTION

The product inspections are the same inspections that are currently performed on the TI products. These inspections on current QA functions were described briefly in the previous Section 2.1 (Block 5) and are applicable to the intermediate and final products of the TI development.

These inspections include assessment of the quality of the mechanical production of the TI and of the composition of the TI. Validation/verification procedures ensure the technical accuracy and completeness of the product. The validation and verification also ensure that the procedural activities described in the TI are accurate and efficient for the performance of the task and that the TI is applicable. Revisions, corrections, and additions or deletions to the TI can result from the validation and verification procedures.

The composition inspections are concerned with spelling, grammar, technical control, format, logical organization of data, text completeness, continuity, and ease of access to the needed information. Inspections will also be implemented to insure the inclusion of engineering review comments, validation corrections, and verification revisions.

The production quality criteria are concerned with format of title page and front matter, figure references and titles, type size, figure quality, proper page makeup and numbering, classification, and specification compatibility.

Contractors have extensive checklists with inspection criteria for these characteristics of the TI. The statistical sampling procedures used for QA indicators may also be applied to the inspections of these characteristics. To inspect <u>all</u> TI for <u>all</u> the possible characteristics of the above listed categories would be a limitless task. While a large part of the current QA effort is concerned with these inspections, it is considered that with a greater use of sampling techniques, along with the incorporation of the process of using quality indicators, a more prudent and efficient inspection of the TI products will be possible.

4.3.3 SAMPLING (Data Base Quality - Estimation)

Regardless of the ability of the writer, missing or obsolete data will prevent his writing a high quality technical document. The quality of the data base he uses can be evaluated by the tedious and costly 100% audit method (in practice even this expenditure of time and effort cannot guarantee that all errors will be deleted). In lieu of a 100% audit of the data base, statistical sampling can be used to estimate the quality of the data base. The overall practicality of using sampling to estimate quality is illustrated by increasing usage by defense agencies such as the Defense Contract Audit Agency (DCAA). [5] For additional rationale for using sampling see MIL-STD- 105 D, Sampling Procedures and Tables for Inspection by Attributes. [6] In the paragraphs that follow, a statistical test plan is outlined which is tailored to estimate the quality of the TI development and products. The test plan is applicable to both the QA indicators and the product inspections.

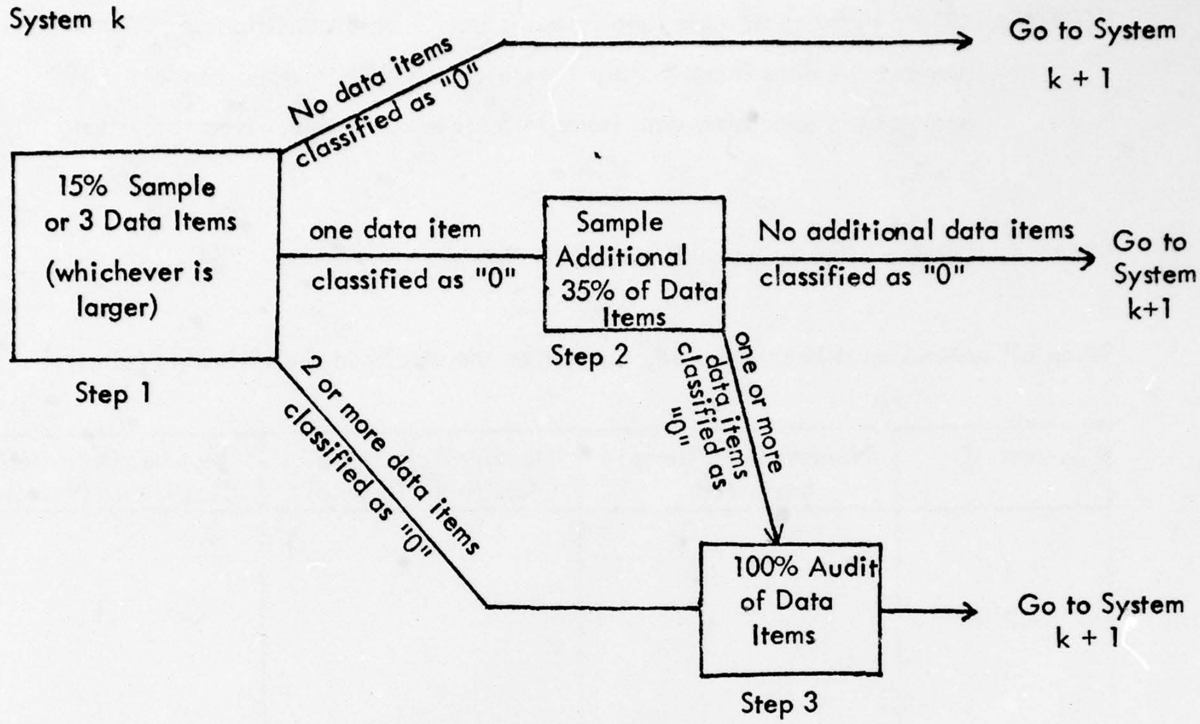
4.3.3.1 STATISTICAL PLAN

The TI data base is assumed to contain information for k systems with n_k data items for the k^{th} system. "System" is used as a generic term in this development, it can refer to a hardware system, a subsystem, or any other desired classification of hardware items. The data items will be coded as a "0" (zero) or a "1" (one) in accordance with the following:

"1" = data item is fully acceptable

"0" = data item is not fully acceptable; i.e., it is absent or late

A multiple stage sampling plan is outlined in Figure 4-3.



Note: If required sample size is fractional, round to the next larger integer.

FIGURE 4-3

STEP 1: Select a 15% sample of the data items or 3 data items (whichever is larger) at random from system k (e.g., system 1). If there are no data items classified as "0" skip the remaining steps and go on to System k + 1 (e.g., system 2). If there is one data item classified as "0" -- proceed to Step 2. If there are 2 or more data items classified as "0" skip Step 2 and proceed to Step 3.

STEP 2: Given that one data item was classified as "0" in Step 1, then select a random sample of an additional 35% of the data items in System k. If there are no additional data items classified as "0" skip Step 3 and go on to system k + 1. If there are one or more additional data items classified as "0", proceed to Step 3.

STEP 3: Given that one or more data items in Step 2 were classified as "0" or if two or more data items in Step 1 were classified "0", then conduct a 100% audit of the remaining data items in System k, -- then go on to System k + 1.

STEP 4: Correct all data items classified as "0" 's.

When all systems have been sampled, summarize the results in the following format:

System ID	Number Data Items Inspected	Number Data Items Classified "1" (one)	Number Data Items Classified "0" (zero)
1			
2			
3			
.			
.			
.			
k			
TOTALS			

Methods to estimate the quality of the data base from these tabulated results will be presented in the next section.

The analysis will be based on the assumption that data item classification* is a Bernouilli random variable. The only assumptions required are that data items can be classified as acceptable or unacceptable, and that a randomly selected data item will have a probability of being acceptable, P, which is between zero and one inclusive. This random variable, X, is characterized by its probability function as follows:

$$\begin{aligned} \text{Prob } (X = 1) &= P \qquad \text{for } 0 \leq P \leq 1 \\ \text{Prob } (X = 0) &= 1 - P \end{aligned} \tag{1}$$

* classified as "0" or "1"

The mean of this distribution is given by:

$$1 \cdot \text{Prob } (X = 1) + 0 \cdot \text{Prob } (X = 0) = P \qquad (2)$$

The variance of this distribution is given by:

$$1^2 \cdot \text{Prob } (X = 1) + 0^2 \cdot \text{Prob } (X = 0) - (\text{Mean})^2 = P - P^2 \qquad (3)$$

(Note that the variance increases as P drops from 1 to .5, achieving its maximum at $P = .5$.)

The probability that a randomly selected data item from system k will be classified "1" has probability P_k. P_k is an unknown parameter which can be estimated from the results of a random sample.

Let N_{sk} denote the number of items in the sample, chosen from system k, which were classified as "1".

Let N_{fk} denote the number of items in the sample, chosen from system k, which were classified as "0".

An unbiased estimator, $\hat{P}_k$, of the unknown parameter P_k is:

$$\hat{P}_k = \frac{N_{sk}}{N_{sk} + N_{fk}}$$

P_k is statistically known as a point estimator of P_k. It may be larger than P_k or smaller than P_k. Management decisions are frequently made to guard against "worst case" quality problems. An estimated 100 γ%* confidence lower bound on P_k can be computed based on the sample data. The calculations are more complex, but they have been extensively discussed and tabulated in NAVWEPS Report No. 8090, "Binomial Reliability Table (Lower Confidence Limits for the Binomial Distribution)".[7] Denote this lower bound by $P_{k \text{ lower}}$. A confidence level, 100 γ%, is associated with this lower bound to specify how sure one wants to be that the estimated lower bound is lower than P_k. (This procedure is the same as computing a 100γ% one-sided confidence interval on P_k.

* γ - gamma

Both the point estimate and the lower bound or worst case estimator should be computed for each system. If repeated sampling is carried out about 50% of the estimators $\hat{P}_k$ will exceed P_k, but only 100 (1 - γ)% of $\hat{P}_{k\ lower}$ will exceed P_k.

An overall measure of the quality of the data base will be formulated in a flexible manner to allow the Navy the opportunity to weight some systems more heavily than others.

Define $P_{tot} = W_1 P_1 + W_2 P_2 + \ldots + W_k P_k$ (5)

where the P_k are previously defined,

where the W_k are weights such that

1. $W_k \geq 0$
2. $\Sigma_k \; W_k = 1 =$ All k

P_{tot} can be estimated using the previous estimates of $\hat{P}_k$'s as follows:

$$\hat{P}_{tot} = W_1 \hat{P}_1 + W_2 \hat{P}_2 + \ldots + W_k \hat{P}_k \quad (6)$$

The Navy determines the weights based on the relative importance of the systems. If the Navy does not wish to make a judgement about the relative weights, then set $W_k = \frac{1}{k}$ for all k.

A value for P_{tot} can be used to pass or fail the TI data base (it is a measure of overall quality ranging from "0" for extremely poor quality to "1" for a very high quality data base). The approach described provides the evaluator of a TI data base with measures of the average quality and "worst case" quality for each system and with a measure of the overall quality of the TI data base. A summary of the statistical parameters and estimators used to measure quality is presented in the following chart.

STATISTICAL PARAMETERS AND ESTIMATORS		
Symbol	Description	How Obtained
P_k	Percentage of data items in system k that are fully acceptable	unknown ($\hat{P}_k$ used as estimator)
$\hat{P}_k$	Unbiased estimator of P_k	computed from data
$\hat{P}_{k\ lower}$	Lower bound on P_k such that Prob $(P_k > \hat{P}_{k\ lower}) = \gamma$ where $100\gamma\%$ is the confidence level	computed from data
P_{tot}	Weighted percentage of data items across all systems that are fully acceptable	unknown ($\hat{P}_{tot}$ used as estimator)
$\hat{P}_{tot}$	Unbiased estimator of P_{tot}	computed from data

4.3.3.2 SAMPLING PLAN CHARACTERISTICS

The sampling plan previously presented has been designed to be practical and is based on fundamental statistical principles. Practicality demands that the plan be simple to keep sampling costs to a minimum and to maximize the intuitive understanding of the plan. A basic statistical principle is to sample more frequently from systems (categories) that have larger variances than from systems that have smaller variances (see Des Raj, Sampling Theory [8]). To apply this principle to the present situation we noted that systems with decreasing quality (decreasing probability that a sampled data item would be classified "1") had larger variances (see para. 4.3.3.1). Therefore, systems indicating lower quality should be sampled more frequently, which is also intuitively appealing. The proposed plan radically increases the sample size in a system upon indication of quality problems.

The sensitivity of the plan can be assessed quantitatively by computing the probability of detecting unacceptable data items in the data base as a function of the frequency of existence of unacceptable data items in the data base. As the quality level in a system decreases, the probability of detecting the lack of quality increases rapidly. The sampling procedure has most difficulty detecting isolated data-item deficiencies, but if some problem (such as schedule slippage causing late releases of data items for a system) is systematically generating deficient data items, then the plan would have good sensitivity. Three examples follow which show the sensitivity (probability of detecting a "0") of the plan for various numbers of defective items in the system.

Example 1: A system has twenty (20) data items from which a sample of size 3 is to be selected.

Number of the 20 data items that are "0" 's	Probability of getting 1 or more "0" 's in sample
2	.284
4	.509
6	.681
8	.807
10	.895
12	.951
14	.982
16	.996
18	1.000
20	1.000

Example two shows that the sensitivity of the first stage increases with increasing sample size even if the percentage of defective items remains constant (compare with example 1).

Example 2: A system has forty (40) data items from which a sample of size 6 (15%) is to be selected.

Number of the 40 data items that are "0" 's	Probability of getting 1 or more "0" 's in sample
4	.493
8	.764
12	.902
16	.965
20	.990
24	.998
28	.9998
32	.999993
36	1.000
40	1.000

Example three shows the sensitivity of the second stage of the sampling plan to the number of deficient items in the system. In order to be in stage 2, some indication of a quality problem was exhibited in stage 1; therefore, it is desirable to have much greater sensitivity in the second stage. Comparison with example 1 shows this to be true.

Example 3: A system has twenty (20) data items. During the first stage, an item classified as a "0" appeared in the sample of size 3. An additional sample of size 7 is taken.

Number of the remaining seventeen (17) data items that are "0" 's	Probability of getting 1 or more "0" 's in 2nd stage sample
0	0
2	.669
4	.912

(Example 3 - Table - Continued)

6	.983
8	.998
10	.99995
12	1.000
14	1.000
16	1.000
17	1.000

All calculations in examples are based on Hypergeometric Probability Distribution since sample replentishment is not assumed.

Informal Note: Hypergeometric Probabilities

Notation: Let
$$\begin{cases} n = \text{Total items in a category} & n = 1, 2, 3, \ldots \\ s = \text{Number of the } n \text{ items sampled} & 0 \leq s \leq n \\ t = \text{Total "bad" items of the } n & 0 \leq t \leq n \\ r = \text{Number of "bad" items in the sample of} \end{cases}$$
size s $\quad 0 \leq r \leq s \leq n, \quad 0 \leq r \leq t$

The probability of exactly r "bad" items in the sample is:

$$\frac{\binom{t}{r}\binom{n-t}{s-r}}{\binom{n}{s}} \quad \text{for} \quad \begin{matrix} 0 \leq r \leq s \leq n \\ 0 \leq r \leq t \end{matrix}$$

(Hypergeometric)

$$0 \qquad \text{otherwise}$$

$$\frac{\binom{t}{r}\binom{n-t}{s-r}}{\binom{n}{s}} = \frac{t!\,(n-t)!\;s!\;(n-s)!}{r!\,(t-r)!\,(s-r)!\,(n-t-s+r)!\;n!}$$

Therefore, the probability of 1 or more "bad" items beingsampled is:

$$1 - \text{Prob} \; (\, 0 \text{ "bad" items in sample }) =$$

$$1 - \frac{(n-t)\,!\,(n-s)\,!}{(n-t-s)\,!\,n\,!} \qquad \text{(i.e., when } n = 0\text{)}$$

4.4 IDENTIFICATION OF QUALITY ASSURANCE INDICATORS

A discussion with examples of QA indicators for each phase of TI development is provided in the following sections. As previously discussed, the concept of indicators was developed primarily to serve the early phases of TI Generation. However, it may in part apply to other phases as well.

4.4.1 TECHNICAL INFORMATION GENERATION

This is the phase in which the QA indicators are used. In the early stages of this phase, critical tasks are performed that will insure timely TI with quality. Thus, this phase is discussed in detail with examples for each stage. Figure 4-4 is a Sample Form for listing the relevant QA indicators. This figure will provide a standard method for showing the use of QA indicators in auditing the development of this program.

4.4.1.1 INDICATORS FOR AUDIT OF THE DATA MANAGEMENT PROGRAM DEVELOPMENT

The organization and establishment of the Data Management Program represent the cornerstone of performing QA audits of the activities during the early stages of TI development. This program establishes the data-gathering network procedures and the data-logging procedures. Therefore, the monitoring of the development of the Data Management Program by QA personnel is of considerable importance. The format of Figure 4-4 will be used for listing the relevant QA indicators presented in Table 4-1.

4.4.1.2 INDICATORS FOR AUDIT OF THE DESIGN ANALYSIS

The design analysis consists of all the analyses required for formulating the content(s) and form of the TI. The format selection, User-Data Match, and Head/Book Trade-Off

QUALITY INDICATOR RECORD

MANUAL TITLE ______________________ MANUAL NO. __________ DATE ________

CONTRACT NO. __________ QA REPRESENTATIVE ______________ DATE ________

Quality Indicator	Scheduled Completion/ Release Date	Actual Completion/ Release Date	Data Entered & Available	Physical Location	Logged		Code "1" or "0"
					Out Date	In Date	

SAMPLE FORM

FIGURE 4-4

DATA MANAGEMENT PROGRAM DEVELOPMENT AUDIT

Quality Indicators

1. TI Data Organization Developed
2. Data-Logging Procedures Developed
3. Data-Cataloging System Developed
4. Data-Storage Capacity Acquired
5. Data-Logging Forms Developed
6. Management Forms Developed
7. Liaison with Data-Release Authority Established
8. Procedure for ECP Routing to TI Group Established
9. Release-Schedule Tracking Formalized
10. Liaison with Design and Functional Groups Established and Formalized

TABLE 4 - 1

are updated and cost analyses for the TI are performed. The results of these analyses become vital data for the production of the TI. The QA personnel cannot ascertain the accuracy of the results of these analyses, just as QA personnel cannot insure the accuracy of a stress analysis for the design of hardware. The completeness and the timeliness of the results, however, can be audited by QA personnel. A list of sample QA indicators for this stage of the TI development is shown on Table 4-2. The format of Figure 4-4 should be followed for recording the QA record of the Design Analysis Program.

4.4.1.3 INDICATORS FOR AUDITING THE DATA ACQUISITION PROCESS

The data acquired for the TI development provides the basis for the information contained in the TI. Acquisition of such data must be complete and on schedule to insure that the TI is accurate and complete. The data can take many forms, such as engineering reports and drawings, technical orders for Government-furnished equipment, vendor brochures, and data and reports from the various support disciplines. Data can also be obtained through personal communications with other personnel knowledgeable of the system and by attending design reviews. A sample list of the quality indicators for data acquisition is shown in Table 4-3. In many cases there will be more than one quality indicator for a given data item, (i.e., ECP's, LSAR's, MEAR's, Hazard Analyses, SER's, PPB's), so space should be provided for individual listings. Table 4-4 lists the quality indicators involved in data acquisition and the development of the personnel contacts with personnel in other disciplines. The recording format for these quality indicators should be similar to the format of Figure 4-4. A "Document Entered and Available Date" column and a "Location" column should be included with the "Scheduled Release Date" and "Actual Release Date" columns.

4.4.1.4 INDICATORS FOR AUDITING THE DATA UTILIZATION PROCESS

Data utilization is the general title given to writer activities and training depicted in Blocks 6, 7, and 8 of Figure 3-3. Data utilization audits are made to determine if the writer uses the appropriate information that is available. In this stage, the writer is selected and assigned the development of a given piece of TI or a group of TI items.

DESIGN ANALYSIS AUDIT

Quality Indicators

1. Data Accessing/Indexing Procedure Developed
2. Format Selection Analysis Update Completed
3. Format/Medium Selected
4. User-Data Match Analysis Update Complete
   - Definition of User Characteristics Complete
   - TI Presentation Format Selected
5. Head/Book Trade-Off Analysis Update Complete
   - TI Required Data Specified
6. TI Specifications and Data Item Descriptions Modified

TABLE 4 - 2

DATA ACQUISITION LOG AUDIT

Quality Indicators

1. Procurement and Test Specifications
2. Proposed Technical Description
3. Photos of Mockups or Equipment
4. Support-Equipment Description Data
5. Task Analysis Data
6. Maintenance Concept as Applicable
7. Special User Personnel Qualifications
8. Notes and Materials from Vendors
9. Failure Modes and Effects-Analysis Data
10. Engineering Reports
11. Blueprints/Drawings/Sketches
12. Vendor Brochures and Commercial Manuals
13. Engineering Change Proposals (ECP's)
14. Logistics Support Analysis Report (LSAR's)
15. Maintenance Engineering Analysis Records (MEAR's)
16. Hazard Analysis
17. Subsystem Hazard Analyses
18. Support Equipment Requirements Sheets (SER's)
19. Provisioning Parts Breakdowns (PPB's)
20. Development Hardware Location and Availability

TABLE 4-3

DATA ACQUISITION TASK AUDIT

Quality Indicators

Task I - DOCUMENTATION

1. Release Schedules Established
   - Engineering Drawings
   - Engineering Descriptions
   - Specifications
   - Task Analysis
   - Maintenance Engineering Analysis Data (MEA)
   - Hazard Analysis
   - Support Equipment Requirement Sheets (SER's)
2. Engineering Design Review

Task II - TECHNICAL PERSONNEL LIAISON

1. Design Engineer
2. Maintenance Engineer
3. Training Engineers
4. Reliability Engineer
5. Human Factors Engineer
6. System Safety Engineer
7. Production Supervisor

TABLE 4-4

The writer also undergoes training and certification during the data utilization phase. The certification process ensures that the writer is knowledgeable of the specifications and requirements imposed by the customer, understands the analyses results, and is knowledgeable of the company's special TI formats and guides for writers. The writer is also trained in the organization and logging of data and in the overall data-management program. Table 4-5 lists the quality indicators which could be used by QA personnel to track and audit the performance of data utilization functions.

4.4.1.5 INDICATORS FOR DRAFT PREPARATION AUDIT

The QA indicators as shown in Table 4-6 follow the progress of the preparation of the TI draft. No effort is made by the QA personnel to edit the draft, but only to monitor its progress. The recording format for this table should be similar to Figure 4-4.

4.4.1.6 INDICATORS FOR DRAFT VALIDATION AUDIT

Validation of the draft TI is performed by contractor personnel at the contractor's facility. The QA indicators shown in Table 4-7 are concerned with the preparation for completion of validation and the insertion of corrections (resulting from the validation) into the draft. Records should be in a format similar to Figure 4-4, with a Draft Validation Audit form for each piece of TI to be validated. It is expected that the validation will be based on the real hardware, and will not merely consist of a visual inspection.

4.4.2 INDICATORS FOR CARRYING OUT THE TI FINAL REVIEW

The later phases of the TI preparation are grouped together for discussion because these are the phases where definite products are involved and inspections become the prime QA method, rather than use the quality indicators. However, QA indicators are still a useful means of insuring proper progress of the TI development during these phases, and examples of the indicators are provided in Table 4-8. Records should also be in a format similar to Figure 4-4. Again, the indicators measure the scheduled completion of the tasks to be performed in these phases.

DATA UTILIZATION AUDIT

Quality Indicators

PART I - WRITER QUALIFICATIONS

1. Writer's Name
2. Writer Certification
3. Writer Selection

PART II - DATA ITEM CHECKOUT LOG

1. Data Item

   (Each item of data will be listed, with dates for logging in and out)

PART III - WRITER LIAISON RECORD

1. Group or Person Contacted

   (Each group or person contacted will be listed with date of contact)

PART IV - NAVY QA PERSONNEL REVIEW MEETING

1. NAVY QA Contact

   (Navy QA personnel contacted will be listed and date of contact)

TABLE 4 - 5

DRAFT PREPARATION AUDIT

Quality Indicators

1. TI Outline Complete
2. Illustration Requirements to Illustrators
3. Illustrations Complete
4. Draft Complete
    - 20% Complete
    - 40% Complete
    - 60% Complete
    - 80% Complete
5. Draft Edited
6. Draft Proofed

TABLE 4 - 6

DRAFT VALIDATION AUDIT

Quality Indicators

1. Validation Plan Complete
2. Hardware Available
3. Support Equipment Available
4. Personnel Notified and Available
5. Validation Performed
6. Draft Revisions Formulated
   - Text
   - Illustration
7. Draft Revisions Incorporated

TABLE 4 - 7

TI FINAL REVIEW

Quality Indicators

1. Typographic Composition
2. Proofing of Text
3. Reproducible Text
4. Produce Customer Review Copies
5. Review Package to Navy
6. Incorporate Navy Comments
7. Final Navy Review and Approval
8. Release for Preliminary Replication
9. Preliminary Distribution to Navy of Final Copies for Verification
10. Preparation of Navy Verification Plan and Support of Navy Verification
11. Receive Verification Comments
12. Corrections to TI Masters
13. Produce Navy Review Copies
14. Review Package to Navy
15. Navy Review and Approval of Update
16. Release Update for Publication
17. Distribution of Update to Navy

TABLE 4 - 8

4.5 DRAFT INSPECTION PROCEDURES AND CRITERIA

The draft is an intermediate product and is inspectable. The draft can be edited within a technical writing group to the same criteria as the QA personnel use in inspecting the TI draft. The QA personnel may use the same sampling techniques in the draft inspections as are used for the QA indicators. The draft inspections will generally cover format, composition, and content. The technical accuracy, completeness, and usefulness are determined during validation of the draft. The contractor QA will perform sampling inspections and Navy Quality Assurance personnel will sample the contractor QA records to ensure adherence to the quality plan. This is the same multi-tiered QA procedure discussed previously.

The criteria for the inspections are well documented and in current use. Each contractor has checklists of criteria for TI draft inspections. Some variations among these lists exist, but all are composed of criteria set forth by the various TI specifications.

A list showing examples of the existing TI specifications is given in Table 4-9. There are general specifications for TI, and specifications for TI for different types of weapons systems, equipment, and tasks, as illustrated by the table. There are also different specifications for different TI presentation formats such as checklists, illustrations, and procedures.

The contractor criteria checklists are derived from specifications which are applicable to the particular TI draft. A list of criteria is given by Harold E. Price in a report entitled "Development of a Draft Specification for Technical Manual Quality Assurance."[9] Price's list of criteria is similar to, but more comprehensive than, checklists derived by contractors. Table 4-10 is a modification of Price's list. It is a sampling of three criteria of acceptability from each of 21 topics taken directly from Price. Only 63 criteria are listed in the Table from a list of 260 covering over twenty pages in the referenced report. The entire process of QA may include such complex inspection tests as readability and factor determination.

SAMPLE LISTING OF TI SPECIFICATIONS **

MIL-M-38784	Manuals, Technical; General Requirements for Preparation of
MIL-M-38789A	Manual, Technical, Overhaul Instructions with Illustrated Parts Breakdown (For Various Equipment and Accessories)
MIL-M-38793	Manual, Technical, Calibration Procedures, Preparation of
MIL-C-8122b(AS)	Checklists: Flight Crew, Preparation of
MIL-I-28947	Illustrations for Technical Repair Parts Publications, Preparation of
MIL-M-15017G	Manuals, Technical: Equipments and Systems Content Requirements for
MIL-M-22202B	Manual, Technical, Cross Servicing, Schedule (Aircraft) Preparation of
MIL-M-23305	Manual, Technical Operation, Maintenance and Overhaul Instructions with Illustrated Parts Breakdown (For Aircraft Launching and Recovery Equipment) Preparation of
MIL-M-23618D	Manual, Technical, Periodic Maintenance Requirements, Preparation of
MIL-M-23619A	Manual, Technical, Periodic Maintenance Requirements, Maintenance Requirements Cards, Sequence Control Charts, And Related Test Flight Check List, for Air Weapons Systems, Printing and Binding of
MIL-M-7298C	Manuals, Technical: Commercial Equipment
MIL-M-7700A	Manuals, Flight
MIL-M-8910	Manuals, Technical: Illustrated Parts Breakdown; Preparation of
MIL-M-9854B	Manual, Technical, Structural Repair (For Aircraft)
MIL-M-81218	Manual, Technical, Aircraft Engine, Intermediate and Depot Maintenance, Preparation of

** Note: This listing denotes various types of specifications for TI, but not necessarily those reviewed for this report.

TABLE 4-9

TABLE 4-10

EXAMPLE DRAFT-INSPECTION PARAMETERS
AND CRITERIA OF ACCEPTABILITY *

1. ORGANIZATION

A. Principal Units and Work Packages

1. Manual organization is based on a hierarchy of maintainable units or equipment.
2. Manual organization is compatible with a family tree or topdown breakdown of maintainable units or equipment.
3. Presentation of equipment or work units follows a logical organization such as order of use, maintenance hierarchy, or is arranged according to data flow.

B. Arrangement within Sections or Packages

1. All information concerning a maintainable unit is consolidated into a single package.
2. The content, format, and sequence of information within a package are standardized.
3. A "local" table of contents is included to indicate material available within a section.

C. Composition Practices

1. There is approximately one heading for every two paragraphs.
2. Headings are set off by spacing, printed in bold lettering, or otherwise emphasized.
3. The ratio of major headings to subheadings is not larger than 1 to 10.

D. Prose-Graphic Balance

1. Approximately half of the material in the manual is text and half is graphic.
2. Any imbalance between narrative and pictorial favors pictorial in order to minimize procedural errors and performance time.
3. Pictorial information is provided when steps refer to:
   a. a particular equipment location,
   b. the relationship between two or more equipment items,
   c. a specific equipment manipulation (e.g., valve rotation),
   d. a test readout which is continuous (e.g., waveform) rather than discrete (e.g., numerical value).

2. PROSE COMPOSITION

A. General Style Principles

1. A nomenclature pictorial is presented at the beginning of a section.
2. Pictorials are used to introduce key equipment terminology used in prose discussions.
3. Short familiar names are used for hardware once it has been introduced. For example, after referring to a "videodisc proportional spacing word processor with high speed printer," further discussion can simply use the "word processor".

* This Table taken from Reference 9, by H. E. Price

TABLE 4-10
(continued)

B. Instructional Writing
   1. Ninety percent of the maintenance instructions are proceduralized.
   2. Each procedural step has no more than three sentences.
   3. "Second person imperative" is used for instructions, e.g., "Turn the Sensitivity Control to maximum".

C. Paragraphs
   1. Short thought units of "chunks" of information are used in preference to longer units.
   2. Paragraphs are short and have topic sentences.
   3. Longer sections of material start with a summary.

D. Sentences
   1. Sentences generally contain a single idea or thought.
   2. Sentences are limited to 17 to 20 words.
   3. Common and unambiguous verbs are used.

E. Words
   1. There is an average of 1.5 syllables per word based on a count of at least 100 words.
   2. Lengthy words are eliminated or "diluted". Use common words in place of less familiar words.

Simple	Awkward
about	as to, with regard to
after	subsequent to
because	inasmuch as, for the reason that
call for	necessitate, require
enough	sufficient
find out	ascertain, determine
for	for the purpose of
get	acquire, obtain, receive
if	in the event that
now	at this time, presently
of	relative to, with regard to
since	inasmuch as
use	utilize

   3. Simple prepositions are used.

Simple	Awkward
like	along the lines of
to	in order to
by, under	in accordance with
to	with a view to
about	with reference to
so that	with the result that

TABLE 4-10
(continued)

F. Non-Text Words and Phrases
   1. Labels and titles of graphics indicate what they are about.
   2. Nomenclature in the text is defined the first time it is used.
   3. Headings are no more than 3 or 4 words.

G. Legibility
   1. Page layout generally enhances reading speed and comprehension.
   2. Double column format is used for prose.
   3. Ideal line length is between 14 picas (2-5/16") and 23 picas (3-13/16"). One pica equals 0.166 incles.

3. GRAPHICS COMPREHENSION

A. General Graphics Principles
   1. General appearance of each graphic page is good. There are no smudges, white space is evenly distributed and graphics appear uncrowded.
   2. Relation of elements on a page is clear.
   3. Graphic fidelity is kept to the minimum needed for the task at hand.

B. Graphic Form Selection
   1. "Symptom-probable cause-remedy" troubleshooting charts are used where possible causes do not number more than 13 items, and where not more than two or three of these are probable.
   2. System-analysis checklists are used in complicated checkout procedures which require checkout of more than one component.
   3. Photographs are used instead of drawings in cases where drawings would need more than very common geometrical shapes to represent the components.

C. Schematic and Wiring Diagram Practices
   1. Piece part detail is only shown when replacement is authorized at that level.
   2. The superordinate units containing the circuitry are identified.
   3. Procedural support is provided for complex portions of wiring and schematic diagrams.

D. Network Diagram Practices
   1. Different information elements on diagrams are separated by distance, shading, boxes, or some other method.
   2. The information elements of network diagrams are either familiar symbols, readily understandable alphanumerics or labels, or pictorials.
   3. MDCs (Maintenance Dependancy Charts) connectives and leader lines do not overlap function codes.

TABLE 4-10
(continued)

E. Block Diagram Practices
   1. Direction arrows are used to show flow.
   2. Flow is left to right and top to bottom.
   3. Height to width ratio of 2 to 3 is used for functional flow blocks.

F. Illustrations Practices
   1. Line drawings are used to emphasize relevant items rather than to faithfully portray physical fidelity.
   2. Relation of parts in exploded views is indicated by axis lines or other obvious connecting lines.
   3. Any feature of a drawing referred to in the text is at least as large as the text type size.

G. Freestanding or Series Pictorials
   1. In a series of drawings, the first one provides orientation with respect to the major end item of equipment.
   2. Arrows or lines show progression from less to more detailed drawings.
   3. Relation of elements in a series of pages of sequential figures is clear.

H. Table Practices
   1. Interpolation is not required in numerical look-up tables.
   2. Title reflects content variables.
   3. Headings are clear and scale units are included as needed in headings.

I. Graph Practices
   1. Graphs usually have only a single concept.
   2. Comparison between data is shown on the same graph.
   3. Graph scales do not distort the intended relationships.

J. Photograph Practices
   1. Photographs show equipment from the technician's view.
   2. Photographic views indicate uncommon shape or dangerous components.
   3. Photographs are retouched to help orientation of the workers.

Not all factors inspected are of equal importance or criticality to the quality of the TI. A judicious ranking of the criticality of each factor within a given category might further enhance the quality of the TI by providing a criticality bias to the sampling performed. Editors and inspectors currently performing 100% inspections of all factors are perhaps already unconsciously biased in this manner. Experimentation might prove biased sampling to be a viable alternate to a straight random sampling of the material to be inspected.

The validation of the draft determines the accuracy, completeness, and usability of the material. The validation process determines whether the TI is correct and whether the TI is sufficient to allow the desired task to be performed efficiently, safely, and without error. Price's report (referenced above) provides a checklist for determining the Job Performance Adequacy of a TI. A sample of these parameters and criteria is provided in Table 4-11. This Table provides the proper task-performance emphasis that is applicable to the validation phase of the TI Generation. Table 4-11 specifically addresses the validation (or verification) process and suggests a procedure to follow in determining the quality of the product.

The validation of the TI is an explicitly stated contractual requirement and documentary evidence must be supplied by the contractor to show that the procedure was performed. Further, errors and discrepancies in the TI found by validation are documented and lists of these errors are provided to the Navy together with appropriate corrective actions.

4.6 DISCUSSION OF PSEUDO OR NON-NTIPS TI QUALITY

If the user of the technical information has difficulty in locating and interpreting information contained in manuals, the utility of the data is correspondingly reduced. Because of the mass of technical information required to support a weapon system, some mechanism internal to the Navy must be developed to provide the technical publications organization close contact with user personnel. This close contact should serve two purposes: 1) to ensure the availability of the data and to aid the user in identifying accessing techniques

TABLE 4-11

EXAMPLES OF VALIDATION PARAMETERS AND CRITERIA

OF ACCEPTABILITY FOR TECHNICAL MANUALS *

1. ACCESS AND SEARCH

A. Identification

1. The title page reveals the purpose of the manual and the system or equipment for which it is used.
2. A full-page illustration of the equipment is provided near the front of the manual.
3. Manual breakdown is based on a hierarchy of maintainable units or work packages.

B. Sections or Packages

1. A "local" table of contents is used to indicate material available within a section or package.
2. Test equipment is listed in tables to show how and when it is needed.
3. Tables show availability of test points for use in trouble-shooting procedures.

C. Table of Contents and Headings

1. The table of contents has a logical sequence from topic to topic.
2. The table of contents consistently lists all text headings of the same level.
3. Each heading and subheading is referenced at least once in the table of contents or index.

D. Index

1. Any text heading not in the table of contents is in the index.
2. The minimum number of index headings is one per page of manual content.
3. The index is set up in alphabetical order.

E. Reference Compliance

1. Official part number and nomenclature used on title page to identify the technical manual. (MIL-M-38784)
2. Inclusion of listing of technical directives (changes and bulletins) covered by the manual.
3. Applicable safety precautions included .(MIL-M-38784)

2. USABILITY AND ACCEPTANCE

A. Information Content Adequacy

1. Initial system conditions for maintenance activities are specifically identified for such factors as:
   a. gaining access
   b. removing fluids

* This table taken from Reference 9 by H. E. Price

TABLE 4-11
(continued)

c. pressurizing/depressurizing
d. raising/lowering
e. energizing/de-energizing
f. warm up/cool down

2. Initial equipment conditions, prior to operations or maintenance, are specifically identified for such factors as:
   a. switch position
   b. valve position
   c. recorder settings
   d. meter settings.
3. Maintenance checkpoints are identified and discussed in terms of:
   a. their location
   b. appropriate measurement equipment
   c. tolerances at each checkpoint
   d. parameters for alternate modes
   e. unusual procedures or cautions

B. <u>Job Relevance and Efficiency</u>

1. All information concerning a maintainable unit is consolidated into a single package.
2. Manual sections or packages contain only that information required to support job performance.
3. Information not relevant to the job or excess detail is eliminated.

C. <u>Workpace and User Compatibility</u>

1. The manual specifies what might be done to make the working environment as nearly ideal as possible.
2. Specific instructions are given for special maintenance which might be required in unusual climatic conditions such as cold, heat, wind, altitude, and noise.
3. The manual is constructed so as to allow the removal and addition of pages.

D. <u>Technical Scope and Accuracy</u>

Technical scope and accuracy are not amenable to a checklist type of review. Tests for scope and accuracy are appropriately a part of Validation and Verification rather than In-Process Reviews. The questions of concern are:

1. Is the information in the manual technically accurate?
2. Is there enough information in the manual to adequately support job performance?

As part of the In-Process Review, however, a form of adequacy check may be performed. NAVAIR 00-25-600 defines an adequacy check and suggests a procedure as indicated below:

TABLE 4-11
(continued)

The objective of an adequacy check is to determine the degree to which depth and scope of coverage in maintenance manuals, and the parts listing and breakdown in IPB's (Illustrated Parts Breakdowns) are sufficient to support repairables, replaceables, and items to be assembled or manufactured within the Navy establishment.

To perform an adequacy check, it is advantageous to work in groups, one person working with the Provisioning Parts Breakdown (PPB), one with the IPB and one with the maintenance manual. The person with the PPB searches out items coded repairable, replaceable, to be assembled, or to be manufactured. The part number and nomenclature of these items are called out along with the source code, and the person working with the IPB determines if it contains the proper artwork and parts breakdown. The person working the maintenance manual ascertains if the depth of coverage supports the source/maintainability/recovery code. At the same time, the approved support-equipment listing can be checked to insure that support equipment called out in the maintenance procedure is approved and compatible.

which minimize the time required to identify the needed technical documentation, and 2) to provide for a feedback loop for correcting any deficiencies found in the technical documentation by the user. In order to facilitate the corrections of deficiencies, the normal chain of command should be bypassed to permit direct access to the organization responsible for making the correction.

SECTION 5
RECOMMENDATIONS AND CONCLUSIONS

5.1 GENERAL

The review of the documentation on current technical publications development in NTIPS has led to the general conclusion that all of the contractor activities should be formalized and defined carefully by the contractor prior to the initiation of any TI program. There are formal requirements for text generation and illustration preparation in the form of specifications and handbooks. There are no formal requirements for the processes of data *acquisition, analysis* of *technical* publication requirements and writer training. In order for TI Generation to be economical, efficient, and of high quality, careful planning must be carried out in the areas of data acquisition, analysis, and writer and illustrator training. In order to ensure contractor compliance with the requirements, the Navy must develop procurement documentation in the form of Specifications, Standards, and Data Item Descriptions. Close surveillance of the contractor TI Generation program by contractor QA personnel is also necessary.

5.2 PROGRAM PLAN

As part of his proposal, the contractor should prepare a detailed Program Plan, preferably in specification format, to permit Navy evaluation of the contractor's understanding of the overall Technical Publications effort. Prior to contract award, the Navy should review and request changes as necessary to the plan submitted by the contractor, and permit only approved changes to the implementation of that plan during the contract performance.

5.3 DATA MANAGEMENT

The data management process is crucial to the success of TI Generation. The effectiveness of the TI is in direct proportion to the adequacy and availability of the data used as the raw material for TI Generation. It is therefore strongly recommended that the data management process be formalized and monitored by both management and QA personnel.

5.4 ANALYSES REPLICATION

In order for the analyses to be useful, they must be carried out to the task level during the contractor replication of the Navy preliminary analyses. However, no analysis should be undertaken unless the products of the analysis in both content and format are directly usable by the writer. To ensure that the results of the analysis are available when needed by the writer, analyses planning and scheduling should be formalized and addressed in the Program Plan.

5.5 WRITER, ILLUSTRATOR, EDITOR, TRAINING AND CERTIFICATION

Training is the primary mechanism for controlling writer, editor, and illustrator behavior. It is essential therefore, that this training be comprehensive and complete, not only with respect to the technical nature of the task, but also in the area of organizational procedures which will facilitate the successful implementation of the writing task. The formal development of effective comprehensive training programs should be monitored closely by both management and QA personnel.

5.6 DATA UTILIZATION

Records of the data used by writers and illustrators should be maintained in order to verify that the writer has available the most recent information to serve as the raw material for his final product. The writer should be responsible for maintaining a record of this material.

5.7 DRAFT REVIEW AND FEEDBACK

An essential mechanism for shaping writer behavior is continuous evaluation of his intermediate data products. Mechanical aspects of the review should be implemented with word-processing techniques and should include vocabulary and syntactical elements which may be programmed. This method of objective review of the writer's intermediate products eliminates many mechanical and iterative editing tasks and permits the editor to review more complex and subjective aspects of text and illustration preparation. When editors are relieved of the minor mechanical tasks, they may implement the

subjective review more quickly and thus shorten the feedback time cycle for writers and illustrators. The Navy Quality Assurance personnel should ensure that effective contractor Quality Assurance programs are in turn making sure that the process for evaluation and feedback is functioning well.

5.8 DRAFT VALIDATION

Draft validation should be procedural, and based on actual hardware. Visual validation and validation by inspection of the document are both unacceptable techniques. Validation provides the contractor with a first test of the usability of his product. It must be recognized that a well-written, syntactically correct document may contain technical errors which may not be discovered until an attempt is made to use the document in the manner for which it is intended. Care should be taken in the selection of maintenance and operating personnel who will implement the task during the validation process. Whenever possible, these personnel should be representative of the user population.

5.9 SCHEDULING, DATA RELEASES AND SOURCES, ECP's, MODIFICATIONS AND REVISIONS, PRODUCTION RELEASES AND SCHEDULES

The significance of scheduling all of the tasks associated with TI Generation cannot be overemphasized. Scheduling is the key to ensuring technically correct TI. TI Generation schedules should be based upon hardware development and configuration control programs. Each data release, ECP, specification modification, and production schedule, for each piece of equipment for which technical publications are being prepared, should be monitored and introduced into the TI Generation program in order to maintain input-data control during the development of the technical-publication product. Only through this procedure can accurate, current, and complete technical information be included into the final product.

5.10 CONCLUSION

While it is suggested that all of the above recommendations be incorporated into NTIPS, each recommendation is independent of the other and may be implemented individually.

BIBLIOGRAPHY

1. Hageman, Inc., The Potential Impact of an Effective Quality Assurance Program for Navy Technical Publications on Navy Training and Training Equipment Procurement, Final Report, N61339-76-M-0163, Naval Training Equipment Center, May 1977.

2. NDCP #W-1032-PN (Navy Decision Coordinating Paper), Navy Technical Information Presentation System (NTIPS), David W. Taylor Naval Ship Research and Development Center, S. C. Rainey (Project Manager), under Naval Air Systems Command (Code 340C), March 8, 1978.

3. Block Diagram, Figure 2-2, provided by Mr. S. C. Rainey of the David W. Taylor Naval Ship R & D Center.

4. MIL-Q-9858, Quality Program Requirements, 16 December 1963.

5. Ilderton, Robert S., "Statistical Sampling Facilitated by DCAA Software Programs", Defense Management Journal, Vol. II, No. 4, October 1975, pp. 34-38.

6. MIL-STD-105D, Sampling Procedures and Tables for Inspection by Attributes, 20 March 1964.

7. Cooke, Lee & Vanderbeck, Binomial Reliability Table (Lower Confidence Limits for the Binomial Distribution), NAVWEPS REPORT 8090, NOTS TP 3140, U.S. Naval Ordnance Test Station, China Lake, California, January 1964.

8. Des Raj, Sampling Theory, McGraw-Hill, New York, 1968.

9. Price, Harold E., Development of a Draft Specification for Technical Manual Quality Assurance, BioTechnology, Inc., December 1975.

APPENDIX "A"

GLOSSARY OF TERMS

APPENDIX "A"

GLOSSARY OF TERMS

ACCURACY - The degree of conformity to a standard or model; also degree of freedom from error and discrepancies.

ADEQUACY - Depth and scope of coverage relative to a depth and scope which is sufficient to support all tasks and functions at the prescribed level of the user consistent with the equipment to be used.

AUDIT - A selective comparison standards or objectives.

CUSTOMER - Navy activity responsible for the QA effort to ensure adequacy and accuracy of the technical manual.

DRAFT/DRAFT TEXT/ MANUSCRIPT - The technical data prepared in relaxed format to allow use of cost effective practices and techniques. The preparation and depth of coverage of the data must be prepared in general accordance with the applicable technical manual specification.

FEEDBACK - Information provided to a person performing a task which describes the effectiveness of the performance.

FLESCH COUNT - A measure of reading grade level that involves determination of the average number of sentences per paragraph, the average number of words per sentence, and the average number of syllables per word.

HEAD/BOOK TRADE-OFF - An analysis to determine how much technical information should be included in manuals and job aids, and how much technical information should be included in training curricula. These categories are not intended to be mutually exclusive.

INSPECTIONS - The examination and testing of supplies and services to determine whether they conform to specified requirements.

MANUSCRIPT - (see Draft)

MEDIUM - The substratum upon which the information is "written".

QUALITY ASSURANCE - A planned and systematic pattern of all actions necessary to provide adequate confidence that the item or product conforms to established technical requirements.

QUALITY ASSURANCE INDICATOR - An observable quality program event.

REPLICATION - The process of reproducing technical information in the form and in the medium required by the contract.

SYNTAX - Orderly arrangement of words as elements in a sentence (sentence structure).

TECHNICAL INFORMATION (TI) - All types and forms of technical publications (partial and complete) procured by the Navy with hardware systems for the purposes of maintenance, operation, training, and logistic support.

TI DEFINITION - This NTIPS * phase is the initial phase of the program. It includes data collection; planning; and CDRL, DID's, TMCR's, and detailed TI specifications; and analyses necessary for the preparation of the Request for Proposal (RFP).

TI GENERATION - This NTIPS * phase includes data collection and management, preparing technical-publications planning documents, writing the technical manual, critiquing the technical manual, and performing Validation.

USER(S) - Those personnel (i.e., operators, instructors, maintainers, technicians) who must apply the technical publication in its actual use.

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* NTIPS - Navy Technical Information Presentation System

USER-DATA MATCH - An analysis to determine precisely what technical information the user requires to perform an assigned task in the work environment in accordance with user characteristics and capabilities.

VALIDATION - The process by which the contractor tests a manual for technical adequacy and accuracy. This is accomplished by actual performance of the operating and maintenance instructions (procedural validation) on the system/equipment for which the technical manual is written.

VERIFICATION - The process by which a technical manual is tested and proved by the using activity, under procuring activity jurisdiction, to be adequate for operation and maintenance.

APPENDIX "B"

REVIEW DOCUMENTS
MATRICES

FIGURE 1

GOVERNMENT SOURCE	DOCUMENT TITLE	Readability - Comprehensibility	Personnel Characteristics	Environment	Job Task	Word, General	Sentence	Familiar Words	Quality Assurance (QA)	User/Data Match	Data Acquisition	Content Generation	Media	Technical Manual	Head/Book	I P B ' s	Handbook Evaluation	Maintenance Information	Management
MIL-M-6300C	Manuals, Technical, General Preparation Instructions for Manuscripts and Illustrations											X		X					
MIL-Q-9858A 16 Dec 1963	Quality Program Requirements								X										
MIL-M-9868/1A(Ships) 30 Mar 1973	Microfilming of Engineering Documents, 35MM												X						
MIL-M-15071G (Navy) 1 Aug 1969	Manuals, Technical: Equipment and Systems Content Requirements for													X					
MIL-M-21742A (Navy) 5 Feb 1971	Manuals, Technical: Overhaul Electronic and Interior Communications Equipment: Content Requirements for													X					
MIL-M-23305(Wep) 5 Jun 1962	Technical Operation, Maintenance, and Overhaul Instr. with IPB (For Aircraft Launching & Recovery Equip)													X				X	
MIL-M-24100B 2 Jan 1974	Manuals, Technical: Functionally Oriented Maintenance Manuals (FOMM) for Equipment and Systems													X				X	
MIL-M-24365 (Ships) 20 July 1970	Maintenance Eng. Analysis Establishment of, and Procedures and Formats for Assoc. Documentation, Gen.																	X	X
MIL-P-28759 (EC) 25 Feb 1971	Planned Maint. Subsystem (PMS) for Shore & Shipboard Equipments, MRC's & MIP's; Prep. and Content of																	X	X
MIL-M-38784A 1 Jan 1975	Manuals, Technical: General Style and Format Requirements													X					
MIL-T-50301 (MU) 6 May 1969	Technical Data: Quality Control System Requirements for								X					X					
MIL-M-632XX (TM) 31 Jan 1973 (Draft)	Preparation of Improved Technical Documentation and Training Part I, JPM and JPG				X														
MIL-M-631XX (TM) 28 Feb 1975	Preparation of Organizational Maintenance Technical Manuals													X					
MIL-M-81203A (AS) 28 Feb 1975	Manuals, Technical, In-Process Reviews, Validation, and Verification Support of								X					X					
MIL-M-81260A (AS) 28 May 1971	Manuals, Technical, Aircraft/System/Equipment Maintenance													X				X	

FIGURE 1

GOVERNMENT SOURCE	DOCUMENT TITLE	Readability - Comprehensibility	Personnel Characteristics	Environment	Job Task	Word, General	Sentence	Familiar Words	Quality Assurance (QA)	User/Data Match	Data Acquisition	Content Generation	Media	Technical Manual	Head/Book	I P B ' s	Handbook Evaluation	Maintenance Information	Management
MIL-M-81273A(Sup 1A) 25 Apr 1966	Manual, Technical, Gen. Spec. for													X					
MIL-M-81701B (AS) 15 Mar 1976	Manuals, Technical, Airborne Missiles and Guided Weapons, Preparation of (Microform Compatible)												X	X					
MIL-M-81702A (AS) 24 July 1972	Manual, Technical, General Airborne Weapons (Conventional)													X					
MIL-M-81748A (AS) 14 July 1975	Manuals, Technical: Rapid Action Changes; Requirements for Preparation of													X					
MIL-M-81919 (AS) 15 July 1973	Manuals, Technical: Support Equipment (Microform Compatible) Preparation of												X	X					
MIL-M-81927 (AS) 15 Feb 1975	Manuals, Technical: General Preparation of (Microform Compatible)												X	X					
MIL-M-81928 (AS) 15 Feb 1975	Manuals, Technical: Aircraft, Equipment, and Component Maintenance, Prep. of (Microform Compatible												X	X				X	
MIL-M-81929 (AS) 15 Feb 1975	Manuals, Technical: Illustrated Parts Breakdown, Preparation of													X		X			
MIL-M-81930 (AS) 1 Feb 1974	Manuals, Technical: 16MM Silver Halide Microfilm; Requirements for												X	X					
MIL-M-81931 (AS) 1 Feb 1974	Manuals, Technical: 16MM Duplicate Microfilm, Cartridge Load & Labeling, Pack.& Ship: Req'mts for												X	X					
Military Specification (Draft - NAVMAT)	Microfiche Technical Manual: Conversion of Existing Technical Manuals to: General Requirements for												X	X					
Military Specification (Draft - Army)	Preparation of Improved Technical Documentation and Training and Training Materials Supporting JPA				X									X					
MIL-STD-105D 20 Mar 1964	Sampling Procedures and Tables for Inspection by Attributes								X										
MIL-STD-109B 4 Apr 1969	Quality Assurance Terms and Definitions								X			X							
MIL-STD-490 30 Oct 1968	Specification Practices											X							

FIGURE 1

GOVERNMENT SOURCE	DOCUMENT TITLE	Readability - Comprehensibility	Personnel Characteristics	Environment	Job Task	Word, General	Sentence	Familiar Words	Quality Assurance (QA)	User/Data Match	Data Acquisition	Content Generation	Media	Technical Manual	Head/Book	I P B ' s	Handbook Evaluation	Maintenance Information	Management
MIL-STD-499 (USAF) 1 May 1974	Engineering Management																		X
AF HRL June 1977	User Acceptance and Usability of the C-141 Job Guide Technical Order System													X			X		
AF HRL September 1976	Evaluation of Three Types of Technical Data for Troubleshooting													X					
AF HRL-TR-73-43 (II) December 1973	Fully Proceduralized Job Performance Aids Handbook for JPA Developers					X							X						
AF HRL-TR-73-43 (I) December 1973	Job Performance and Draft Spec for Organizational Maintenance								X					X				X	
AF HRL-TR-73-43 (III) Decemb er 1973	Job Performance Aids Handbook for JPA Managers and Training Specialists								X				X						
AF HRL-TR-77-31 June 1977	User Acceptance and Usability of the C-141 Job Guide Technical Order System													X			X		
AF HRL August 1976	Experimental Literacy Assessment Battery (LAB)	X																	
NAVAIR 04A4	Technical Manuals to a Work Package Concept (Technical Documentation Policy and Programs Office)													X					
NAVAIR 00-25-100 1 Mar 1971	Technical Manual Program (NAVAIRSYSCOM)													X					
NAVAIR 00-25-400 1 Aug 1975	Maintenance Plan Analysis Guide for In-Service Naval Aircrafts (Management Manual)																	X	X
NAVAIR 00-25-600 31 Jan 1977	Management of Technical Data, In-Process Review, Adequacy Review, Validation, and Verification								X					X					X
NAVAIR 00-25-601 15 Oct 1973	Management Procedures for Out of Production Category or Aircraft/Equipment Manuals													X					X
NAVAIR 00-25-700 1 Jun 1976 (Prelim.)	Technical Manual Preparation Guide for Technical Writers, Editors, and Illustrators					X	X		X					X					
NAVAIR INST 4855.1B 25 Jun 1976	Quality and Reliability Assurance Program Manual for Naval Air Rework Facilities								X	X									

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DEVELOPMENT OF A QUALITY ASSURANCE METHODOLOGY FOR THE TECHNICA--ETC(U)
MAR 79 D D DEARDORFF, K C HAGEMAN, W HEHS N00019-78-C-0175

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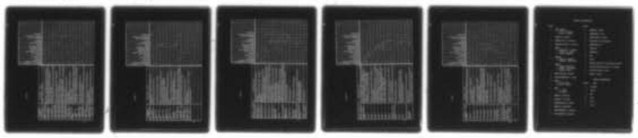

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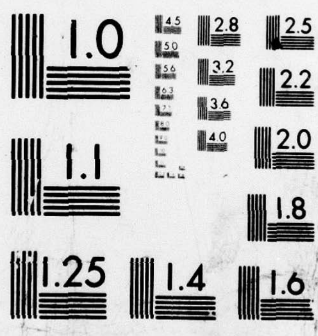

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

FIGURE 1

GOVERNMENT SOURCE	DOCUMENT TITLE	Readability - Comprehensibility	Personnel Characteristics	Environment	Job Task	Word, General	Sentence	Familiar Words	Quality Assurance (QA)	User/Data Match	Data Acquisition	Content Generation	Media	Technical Manual	Head/Book	I P B's	Handbook Evaluation	Maintenance Information	Management
NAVAIR Program Office - Oct 1975	Usability Research in the Navy									X									
NAVAIR TECH SERV FAC - (code 04)	Final Report - Job Performance Aids: Assessment of Needs - A Literature Review (North Carolina State Univ)				X					X			X						
NAVMAT INST 17 Jul 1969	Maintenance Index Page (MIP) and Maintenance Requirement Card (MRC)																	X	
NAVMAT AD-HDC Comm. 19 Arp 1974	Central Management of Technical Manuals for the Fleet													X					X
OPNAVINST 4790.4 CH 3, 10 Feb 1976	Ships 3-M Maintenance, Material, Management Manual (Vol II and Vol III)													X				X	
OPNAVINST 4790.2A CH 5, 15 Dec 1975	Naval Aviation Maintenance Program Vol IV, Machine Records, Reports, and Data Analysis																	X	
OPNAVINST 4790.2A CH6, 20 Sep 1976	Naval Aviation Maintenance Program (Change pages to Vol 1, II, III, and IV																	X	
NAVORD OD-21549 20 Apr 1973	Product Assurance Requirements for Navy Strategic Systems								X										
NAVPHOTOCEN R&D, Nov 1976	Photographic Video Disc Technology Assessment Final Report FY 1976												X						
NPRDC August 1974	An Evaluation of Computerized Tests as Predictors of Job Performances in 3 Navy Ratings: Devel. of Instruments				X														
NPRDC October 1975	Language Skills: A Prospectus for the Naval Services	X																	
NPRDC TR 76-26 December 1975	Personnel Characteristics Relevant to Navy Technical Manual Preparation	X								X									
NTMS-TM-186-76-1 March 1976	Navy Technical Manual System (NTMS Program Summary													X					
NTMS - Report 4483 November 1974	Navy Technical Manual System (NTMS) Program Development Plan													X					
NTMS-TM-186-75-4 December 1970	Test Plan for at Sea Evaluation of Experimental Job Performance Aids (JPA's)				X														

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NTMS - Report 4613 January 1975	Implementation of Program Development Plan During FY 75													X					X
NTMS-CMD-01-75 January 1975	Preliminary Human Factors R & D Plan		X																
NASC October 1974	Job Performance Aids Assessment of Needs												X	X					
NASC October 1974	MIARS: Controlled Tech Data with Microfilm and Trump Mechanized Update Techniques												X	X					
NAVY February 1976	Technical Manual Contract Requirement Aircraft/Equipment A-6E													X					
NPRDC September 1977	Integrated Job Skills and Reading Skills Training System	X																	
TAEG July 1977	Evaluation of Microfiche as an Instructional Medium in a Technical Training Environment												X						
FSD 75-0177 31 Dec 1975	Navy Technical Manual System Publishing System Technology Overview												X	X					
PC-1A-1 (NAVAIR) 10 Aug 1976	Data Management Dept. Stand. Operating Procedures Project Coordinators (Function-Proj.Coor., Task-Respon.)				X														X
H-50 (Off.Sec.of Def.) 23 Apr 1965	Evaluation of a Contractor's Quality Program								X										
US Army Research Institute - Nov 1975	Guidebook for the Development of Army Training Literature									X									
Defense Logistics Agency, March 1977	Quality Assurance Manual for Clothing, Textiles and Life Support Items								X										

FIGURE 2

CIVILIAN SOURCE	DOCUMENT TITLE	Readability - Comprehensibility	Personnel Characteristics	Environment	Job Task	Word, General	Sentence	Familiar Words	Quality Assurance (QA)	User/Data Match	Data Acquisition	Content Generation	Media	Technical Manual	Head/Book	I P B's	Handbook Evaluation	Maintenance Information	Management
Aerospace Industries Assoc. of Amer., Inc.	World Airline Industry Technical Operations Glossary					X													
AIR - American Institute for Research	Improving Reading Comprehension: Measuring Readability	X																	
Biotechnology, Inc.	Requirements and Criteria for Improving Reading Comprehension of Technical Manuals	X								X									
Biotechnology, Inc.	Development of Information Measurement Techniques for Quality Assurance of Navy Aircraft Maint. Aids								X									X	
Biotechnology, Inc.	A Guide for Selecting Formats and Media for Presenting Maintenance Information												X	X				X	
Biotechnology, Inc. (H.E. Price)	Development of a Draft Specification for Technical Manual Quality Assurance								X					X					
Bissell, D.E.	Applying Usability Principles to Overhaul Manuals to Enhance Job Performance									X				X					
Boeing	Handbook for the Design of Training and Training Equipment Requirements for Navy Airborne Weapon Sys.									X									
Booz-Allen Applied Research, Inc.	Research and Development Plan for NAVAIR Documentation Improvement Program Preliminary Report													X					
Brill & Fields	Handbook Evaluation Plan																X		
Courseware, Inc.	A Systems Approach																		
Data-Design Laboratories	Use of Microfische on FBM Submarines												X						
DGA Communications System Development	Current Research on the Relative Effectiveness of Selected Media Characteristics												X						
Grumman	Publications Quality Program								X										
Hughes - prepared by Anacapa Sciences	User-Data Match									X									

FIGURE 2

CIVILIAN SOURCE	DOCUMENT TITLE	Readability - Comprehensibility	Personnel Characteristics	Environment	Job Task	Word, General	Sentence	Familiar Words	Quality Assurance (QA)	User/Data Match	Data Acquisition	Content Generation	Media	Technical Manual	Head/Book	I P B ' s	Handbook Evaluation	Maintenance Information	Management
Hughes - prepared by Anacapa Sciences	Navy Technical Information Presentation Program (NTIPP Human Factors Eng. Support - Progress Rep. #2		X																
Hughes	Preliminary NTIP System Concept and Alternative Configuration - TASK 3 Report (CDRL A003)	X	X	X	X														
Hughes	Technical Writing Style Guide (Review Draft)					X	X	X											
Hughes	The Role of Quality Assurance in the Preparation of Technical Manuals								X					X					
Hughes	Systems/Feasibility Trade-Off Analysis - Establishment of NTIPP Requirements - TASK 2 Rep. (CDRL A002)									X	X	X							
Hughes	Preliminary NTIP System Concept and Alternative Configurations - Addendum - User-Data Match Model									X	X	X	X						
Hughes	Analysis of Current and Proposed Technical Manual Systems - TASK 1 Report (CDRL A001)									X	X	X	X	X					
Hughes	Technical Manual Writing Handbook (Review Draft)													X					
Hughes	Proposal for Navy Technical Manual System (NTMS) Volume II - Scope and Approach			X						X					X				
HUMRRO - Human Resources Res. Organ.	Reading and Readability Research in the Armed Services	X																	
I B M	Functional Objectives Definition												X						
I B M	Navy Technical Manual System Design Analysis Study AN/BQQ Technical Data Product Analysis												X	X					
I B M	Information System Concept									X				X					
Information Concepts Inc., ICI	Improving DoD Maintenance Through Better Performance Aids												X					X	
Lockheed	S-3A Technical Manual Instruction - 33 Format and Style Guide for Development of S-3 Manuals												X	X					

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CIVILIAN SOURCE	DOCUMENT TITLE	Readability - Comprehensibility	Personnel Characteristics	Environment	Job Task	Word, General	Sentence	Familiar Words	Quality Assurance (QA)	User/Data Match	Data Acquisition	Content Generation	Media	Technical Manual	Head/Book	I P B's	Handbook Evaluation	Maintenance Information	Management
Lockheed	Publications Quality Control Group, Procedures for								X										
Man Tech	Navy Enlisted Personnel Characteristics Preliminary Analysis		X																
North American	Handbook Evaluation Plan																X		
Pre Tech Appl	Revising Technical Manuals to Improve Comprehension and Utility	X																	
R E M Company	A Critical Evaluation of the Technical Data Develop. Processes for the Prep.of TM's and Training for Maint.										X			X					
R E M Company	(Same title as above) - HF Research of Tech Manual User-Likes/Dislikes									X	X			X					
R E M Company	(Same Title as above) - Data Base Generation										X	X		X					
R E M Company	(Same Title as above) - Maintainer Needs									X	X			X					
R E M Company (George Klare)	A Manual for Readable Writing		X							X									
Sikorsky Aircraft	Quality Assurance Procedures Product Support Publications Department								X										
Soc.for Appl.Learn. Tech.& Log.Manag.Inst.	Invitational Conference on Improved Information Aids for Technicians													X					
SRI - Stanford Research Institute	Requirements and Alternative Designs for Automating the Publication of NAVSEA MOTD at the NSDSA								X										
Univ. of Maryland Powers - for NTIPP	Selecting Presentation Modes According to Personnel Characteristics and the Nature of Job Tasks		X		X								X						

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